THE
POPULAR SCIENCE
MONTHLY.

OCTOBER, 1902.

A STUDY IN PLANT ADAPTATION.

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EVERY one interested in plants knows that they are very dependent upon their surroundings. The atmosphere and soil conditions that suit one species are often totally unsuited to another. In the process of development the different species become structurally and physiologically modified with the change of environment; they take on certain adaptions, where they succeed best, which particularly fit them to their surroundings.

Every plant in order to grow must receive material from the outside and must get rid of waste matter. The plant does not differ in any essential respect from the animal in this regard. So also, the plant, in order to continue from generation to generation, must bear offspring and leave them in situations favorable to their growth.

In all seed-plants the food materials are essentially the same. The ability of a plant, however, to avail itself of these materials depends very largely upon a close correlation between the structure and the physiological activities of the plant organs and its environment. Thus a plant like the apple will not succeed in a hot and arid climate, while, on the other hand, the date will not thrive beyond the limits of the desert.

The sensitiveness of many plants to a slight change in soil or climate and the necessity for a perfect adaptation to a particular environment are illustrated in the very restricted range of many of our native trees and shrubs.

On the Pacific coast the Monterey cypress is only found growing naturally over a strip of territory, south of the Bay of Monterey, about

two miles long and two or three hundred yards wide, and over a still smaller area a little farther south. The California fan-palm only occurs in a few canyons of two mountain ranges in the southern part of the state. The western hop hornbeam is only known to grow over a few square rods of territory in the Grand Canyon of the Colorado river in Northern Arizona. In eastern United States, Torreya only grows in a narrow strip on the eastern bank of the Appalachicola River in Florida; while the Florida yew, which grows in the same region, occupies a still less extended area.

In such cases as these it is likely that the structural and physiological adaptions of the different plant organs have not kept pace with the natural changes in environment. As a result, these trees are not only unable to extend their present range, but are poorly fitted to persist where they now grow and consequently are disappearing. These old types of trees have in the course of ages become inflexible and fixed and are no longer in perfect accord with their environment. More modern types, as illustrated in the various genera of Cactaceae, are more generalized and very readily take on structural and physiological modifications which fit them better to their present environment. It is interesting to note that many of the species which appear to be out of accord with their natural environment often do well under cultivation. The gardener's care in subjecting them to different environmental conditions, particularly as regards food supply, seems to stimulate them and give them new vitality, thus causing them to succeed better than more modern types perfectly in accord with their natural environment. In the latter case overstimulation, induced by cultivation, may from the standpoint of vitality do more harm than good.

The Monterey cypress, although now nearly extinct as a wild plant, is one of the most successful and easily cultivated trees of the Southwest. It appears to be far better in accord with the artificial environment induced by cultivation than it is with its natural environment. The *Franklinia* of our gardens, a small tree first collected by John Bartram in 1765 on the banks of the Altamaha River in Georgia, is successful in cultivation, although as a wild plant it passed out of existence during the past century. It is far more successful in cultivation than the Loblolly bay, an allied species of the same genus which is now growing wild from Virginia to Florida. The Ginkgo, an Asiatic tree of ancient origin, grows remarkably well in cultivation, although at the present time it is not known to grow as a wild plant any where.

Modern plant types that have not yet reached the limits of their distribution and variation, as illustrated in many species of the Compositae, Rosaceae and Cactaceae, are so nicely adjusted to their natural environment that cultivation often tends to diminish their vitality rather than improve it.

It is not to be presumed that every variation in the structure of plant organs is a direct result of adaptations taken on by the plant to protect it from unfavorable factors in its environment. It is the natural, inherent tendency of plants to vary, and when the variation chances to be in a direction that fits it better to its environment, the variation is apt to persist in future generations. There is no apparent reason, however, why in many instances structures may not be present in the plant that are in no sense of direct aid. We should not expect to refer every variation in plant structures to variation in environment. We should, however, expect those species to do best that in their natural

FIG. 1. THE TUCSON PLAINS, SHOWING RANGE CATTLE IN THE DISTANCE FEEDING UPON THE FRUIT OF THE CHOLLA.

tendencies to vary become so modified as to fit them most perfectly to their surroundings.

Each plant organ must not only be adapted for the kind of work that it has to do, but is must be adapted for doing its best under the external influences which enable it to persist in any given form. The foliage leaf bears a definite relation to light and moisture; the leaves of one plant, however, may have quite different requirements as to light and moisture than the leaves of another. Every traveler in our arid southwest has noticed that the leaves of the trees and shrubs are small and thick, or, in some instances, entirely absent as foliage. The reason for this is very clear. It arises from the necessity of the desert plant to expose a comparatively small surface to the intense sunlight and the desiccating action of the dry atmosphere.

The various species of cacti illustrate this necessary correlation between plant structures and environment probably better than any other large group of plants. *Opuntia,* the most important genus, is abundantly represented in the flora of our arid southwest (Figs. 1 and 2) and reaches its maximum development on the Tucson plains in southern Arizona. No less than ninety-two species of *Opuntia* are growing wild in southwestern United States and northern Mexico, selecting for the most part situations that are so dry that few other plants persist where they thrive.

In this article I desire in particular to call attention to the cholla (*Opuntia fulgida* Engelm.) a cactus which grows to the size of a small tree and which reaches its maximum development on the Tucson plains.

FIG. 2. THE CHOLLA AND TUNA, GROWING TOGETHER IN SOUTHERN ARIZONA.

The cholla has probably not yet reached the limits of its variation and distribution, and is one of the most interesting and characteristic plants of the arid regions of the western continent. The organs of this plant are most wonderfully adapted for performing their various functions, to the best advantage of the plant, under what would be with most plants an extremely adverse environment.

The cholla is one of the largest of the cacti having numerous branches. It grows best where fully exposed to the intense glare and heat of the desert sun and where the annual rainfall averages from four to twelve inches. It grows on the dryest upland, on open, porous, limy soil that for months at a time is as dry as powder.

Where it grows best the summer temperature often reaches a maximum of 115 degrees F. and the daily temperature for weeks at a time ex-

ceeds 100 degrees F. during the hottest part of the day. Often for several consecutive months there is no precipitation whatever and much of the rain that does fall only penetrates the soil to the depth of a few inches.

Not only is this cactus, as an individual plant, perfectly equipped by nature to withstand and thrive under this extremely hot and arid environment, but it is splendidly equipped for perpetuating itself by its successful distribution of offspring under conditions which enable them to succeed where on account of lack of moisture most plants would perish.

The roots of the cholla do not penetrate to great depths in the soil as one would at first thought suspect them to do. For the most part they spread out a few inches under the surface. It would be useless for this plant to send its roots to great depth into the soil, because only in rare instances is there any available moisture there. As most rains only penetrate the soil to the depth of a few inches the most moisture is found in the surface soil. These surface roots of the cholla have a different structure from that found in the deeper roots and in the roots of most plants. Their structure is splendidly adapted to enable them to take up water with great avidity when the soil is moist and to survive long periods of drought during which the surface soil is practically air dry.

It would be of no special value to the cholla to absorb large quantities of water when available, if there were no provision made by the plant for storing it, or if through transpiration it were readily given up to the surrounding atmosphere. This cactus is not only remarkably well equipped for storing water in large quantities, sufficient to carry it through months of continuous drought, but it is able to retain this water with wonderful tenacity, only giving it up to the hot and dry air a little each day and taking advantage of each rain to fill its storage tissue.

The structure of the young branches and stems of the cholla particularly adapts them for the storage of water in large quantities. At the height of the growing season or after a prolonged summer rain the stems of this cactus may contain as high as ninety-two per cent. of moisture. During a prolonged drought the percentage of moisture very perceptibly diminishes. The older stems and branches which give strength and support to the tree contain a much larger proportion of woody tissue and consequently serve to a less degree for the storage of water.

The ability of the plant to retain moisture results largely from the comparatively small surface exposed to the dry air and the remarkably thick epidermis and dense spine covering of the branches. The small

surface is chiefly a result of the elimination of the leaves as foliage and the contraction of the branches into thick, short stems as shown in Fig. 3. During the growing season the cholla exposes to the atmosphere less than one fiftieth of the surface which is exposed by the maple of equal weight here in the east.

FIG. 3. THE SHORT, THICK, SUCCULENT STEMS OF THE CHOLLA BEARING CLUSTERS OF FRUIT AND FLOWERS.

Aside from this remarkable diminution of surface, the thick epidermis of the plant almost precludes transpiration at times when the water in the storage tissues begins to run low. The following illustrates how well the plant is adapted for conserving the moisture previously stored in its thick stems. I have cut a branch from the tree in the spring prior to the season of blooming, at a time when the storage tissue was well filled with moisture. I have placed these branches in a perfectly dry room out of contact with moisture. I have seen them continue in growth, and ultimately blossom. I have placed branches of the previous season's growth in open boxes without soil and without access to moisture early in March, and in September have found the branches still succulent and in condition to root and grow when placed in the soil.

Several years ago I removed a large specimen, having a trunk diameter of eleven inches and a height of ten to twelve feet, from the open mesa where it was growing to my garden. The tree was moved in late May when in full bloom. Although the month was hot and dry, the roots were closely pruned and the top left unpruned. The flowers did not wilt as a result of this severe treatment and a full crop of fruit ripened in the fall. This tree, which is illustrated in Fig. 4, suffered no apparent harm in its removal, although probably fifty to one hundred years old.

As a summary it may well be said that the cholla is admirably adapted for absorbing water rapidly, storing large quantities of it, and even when exposed to a very dry atmosphere for a long time retaining it with wonderful tenacity. Provision is also made for undue loss of moisture at times of injury to the epidermis, and the consequent direct exposure of the storage tissue to the dry air. At such times a mucilaginous substance contained in the cells appears on the injured surface, quickly rendering it impervious to moisture.

It is probable that the thick covering of spines is of some value to the plant in protecting it from the full force of the intensely bright sunlight and also of some value in checking transpiration. These ever present and formidable, barbed spines are well illustrated in Fig. 5. They serve their greatest usefulness to the cholla in preventing its destruction by animals and in the important part which they play in the dissemination of the species. All the younger branches of the cholla are soft and succulent and, were it not for their efficient armor

FIG. 4 A LARGE CHOLLA MOVED FROM THE MESA TO THE GARDEN.

of barbed spines, would be quickly destroyed by herbivorous animals. In acquiring a condensed and succulent plant body in order to fit itself to a desert environment the cholla would have courted its own ruin were it not that it acquired a full equipment of spines at the same time. From every standpoint it is, as an individual, admirably equipped for its desert home. It is, however, more than this; it is the best equipped of all desert plants for rapid and wide dissemination. It makes ample provision for its offspring.

The seeds of the cholla, like those of several allied species, rarely if ever germinate on the open mesa. In eight years of observation in its center of distribution I never found a seedling of this plant growing wild. It spreads almost entirely by vegetal dissemination, *i. e.,* by the ends of the branches becoming detached and transported often long distances from the mother plant.

The cholla is perfectly adapted not only for the easy detachment of the ends of the branches, but for their wide dissemination as well. The fruit which hangs from the tree in long, pendulous clusters as illustrated in Fig. 6 is within easy reach of cattle and other large animals.

FIG. 5. WERE IT NOT FOR ITS FORMIDABLE ARMOR OF BARBED SPINES THE CHOLLA WOULD SOON BE DESTROYED BY ANIMALS.

These clusters of succulent fruits are without spines and are for the most part sterile. The fruit from the standpoint of seed production is of very little service to the plant in aiding in its perpetuation and dissemination. Its chief service appears to be to entice animals to the plant that the fragile ends of the branches which become detached at the slightest disturbance may adhere to them and become scattered far and wide.

In order that these fruits may best serve their purpose they are succulent, unarmed and as eagerly eaten by animals when green as when ripe. Moreover they often remain on the plant for two or more years if undisturbed. During periods of scanty forage in the region where the cholla grows it is not an uncommon sight to see the range cattle with their heads literally covered with these formidable cactus burs

which became attached to them in their effort to get the fruit. The spine arrangement of these end branches or burs is such that when they finally become detached from the animals transporting them and fall to the ground, the lower end comes in contact with the soil. As the roots start from this end of the branch the necessity for this provision is very evident. It results from the spines being very short or wanting on the lower end of the short, thick branches.

The special adaptation of the fruit to aid in vegetal dissemination is confined, so far as I am aware, to a few species of the *Opuntia* and reaches its highest development in the plant that I have described above.

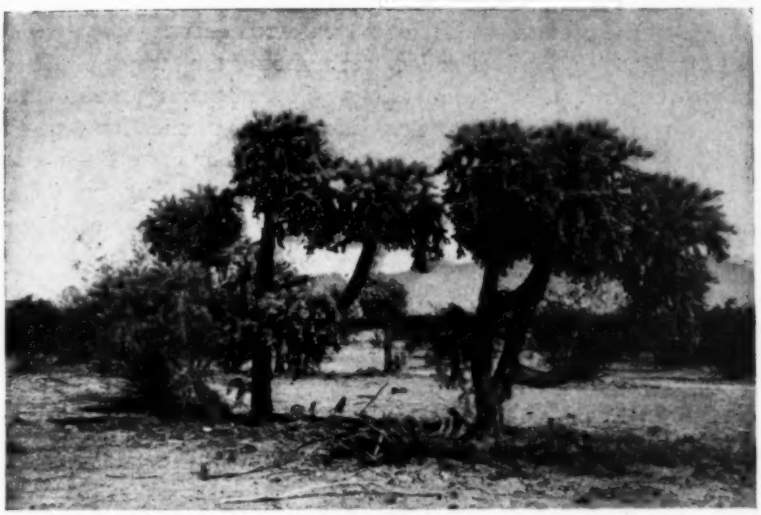

FIG. 6. A GROUP OF CHOLLAS, SHOWING THE LARGE CLUSTERS OF PENDULOUS, SPINELESS FRUIT. PHOTOGRAPHED BY W. T. SWINGLE.

The fruit of the cholla is probably changing from its original seed-bearing condition to a condition of sterility. The abundant clusters of fruit hang from the plant within easy reach of cattle and it is interesting to note that since the advent of stock into the arid southwest the cholla has become more widely distributed and more abundant than ever before. It is as well equipped by nature to care for itself and perpetuate itself on the hot, dry sands of the desert, as is the New England elm of the humid east which bursts into foliage under April showers.

THE AMERICAN ORIGIN OF AGRICULTURE.

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AGRICULTURAL science so generally appears as a borrower from physics, chemistry, botany or zoology that it has not been expected to furnish facts of use in other lines of investigation. Thus, although it has been known since the sixteenth century that the same series of food plants extended throughout the tropics of both hemispheres, the significance of this is still unappreciated, and ethnologists are still doubtful regarding prehistoric communication across the Pacific. Stranded Japanese junks, Buddhist missionaries, Alaskan land connection and other possibilities of contact have been gravely and minutely discussed while unequivocal evidence of extensive early intercourse lay only too obviously at hand.

The history of agriculture shows a conservatism probably unequaled in any phase of human activity. Not only has no important food plant been domesticated in historic times, but even in the most enlightened communities changes in the culture and use of the food plants and products to which our physical constitutions and domestic customs have become adapted take place with extreme slowness except as they accompany movements of colonization. Remembering this strict self-limitation of man to traditional food materials, it becomes obvious that the possession of the same seedless plants, such as the yam, sweet potato, taro, sugar-cane and banana by the primitive peoples of the islands of the Pacific, as well as by those of the adjacent shores of Asia and America, indicates, with attendant facts, not only an older communication, but an intimate contact or community of origin of the agricultural civilizations of the lands adjacent to the Pacific and Indian Oceans.

The Useful Plants of the Pacific Islands.

Notwithstanding the immense distances by which the tropical islands of the Pacific are separated from the continents and from each other, European discoverers found them already occupied by an adventurous sea-faring people who knew enough astronomy to navigate their frail canoes in these vast expanses of ocean without the assistance of the mariner's compass. The agriculture of the Polynesians was, however, no less wonderful than their seamanship, and was certainly not less important to them, since the coral islands of the Pacific are not

only deficient in indigenous food plants and animals, but the natural conditions are distinctly unfavorable to agriculture.

> The whole surface of these flat coral islands is like the clean white-sanded floor of an old English kitchen. The cocoanut tree springs up everywhere, but in the spots where yams and taros are grown the sand is hollowed out, and a pit formed, from one to two hundred yards long, and of varying width, into which decaying cocoanut leaves and refuse are thrown, till a rich soil is formed.*

It is certain, however, that among the Polynesians the cocoanut is a cultivated plant no less than the yam, taro, sweet-potato, sugar-cane, banana, breadfruit and numerous other species found in use throughout the tropical islands of the Pacific. Moreover an especial interest attaches to the cocoanut in that there are adequate botanical reasons† for believing that it originated in America, the home of all related palms.

The agricultural achievements of the Polynesians become the more impressive when we reflect that so many of their cultivated species were not propagated from seeds, but from cuttings. To survive the long voyages in open canoes, these must have been carefully packed, kept moist with fresh water and protected against the salt spray. In the present state of botanical knowledge the number of species thus introduced and distributed by the Polynesians is necessarily uncertain. Many of the economic plants were native in some of the islands of the Pacific, though their constant presence among the peoples of widely separated archipelagos gives sufficient reason for including them in the list of twenty-four species, which Professor Hillebrand‡ believes to have been brought to the Hawaiian Islands by the early Polynesians. This number, however, must be greatly increased, since there were many varieties of the sweet potato, taro, sugar-cane and banana. Moreover the Hawaiian group is scarcely more than subtropical in climate, and lacks numerous seedless sorts of the breadfruit, yam, taro and other plants of the equatorial belt of islands, so that a complete enumeration of the species and varieties carried by the Polynesians would include nearly a hundred.

A detailed study of the distribution, names, cultures and uses of these species and varieties of tropical economic plants would yield information of much value from the agricultural standpoint, but of even greater significance is its bearing upon the origins and migrations of

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* Moresby, 'Discoveries and Surveys in New Guinea,' p. 73, London, 1876. The volcanic islands of Polynesia have, of course, rich soil, but they shared the deficiency of native food-plants from which non-agricultural people could have secured a permanent food supply.

† 'The Origin and Distribution of the Cocoa Palm,' Contributions from the U. S. National Herbarium, Vol. VII., No. 2. Washington, 1901.

‡ Bull. No. 95, Office of Experiment Stations, U. S. Dept. Agri., p. 33.

the ancient agricultural peoples of the Tropics.* At present we have only incomplete and scattered data collected incidentally by missionaries, travelers and professional botanists who did not appreciate their opportunities from the agricultural point of view. But even these miscellaneous facts are often of unexpected interest. Thus, we know that in Central America the use of leguminous shade-trees in cacao plantations was adopted by the Spanish colonists from the natives who furnished even the name 'mother of cacao,' by which the species of *Erythrina* and other leguminous trees are still known in Spanish America. The Indians, of course, were not aware that the roots of the Leguminosæ develop tubercles for the accommodation of bacteria able to fix atmospheric nitrogen; they believed that the 'madre de cacao' supplied water for the roots of the cacao, a fanciful idea still credited by many planters of cacao and coffee. In the Pacific we encounter a similar fact with reference to the yam bean (*Pachyrhizus*), a leguminous vine with a fleshy edible root. The natives of the Tonga Islands no longer cultivate *Pachyrhizus* for food, but they nevertheless encourage its growth in their fallow clearings in the belief that it renders them the sooner capable of yielding large crops of yams. Such anticipations of the results of modern agricultural science are of extreme interest, but it is still uncertain whether similar knowledge exists in other archipelagos of the Pacific, or on the American continent where *Pachyrhizus* probably originated. The botanists report it as 'a common weed in cultivated grounds,' and we learn further that in the absence of better material, the people of Fiji use the fiber for fish-lines, and that the plant sometimes figures in an unexplained manner in their religious ceremonies.

Our knowledge is far from complete regarding even the present distribution of the principal tropical food plants, but the need of further investigation should not obscure the striking fact that several of the food plants with which the Spaniards became acquainted in the West Indies were also staple crops on the islands and shores of the Pacific and Indian Oceans, and even across tropical Africa.

Ethnologists who might have appreciated the bearing of this have passed it by because of the absence of maize or Indian corn among the Polynesians. But in addition to the unreason of accepting negative evidence as an offset for positive fact, two pertinent considerations have been overlooked, first, that most of the varieties of maize do not thrive in the humid climates of the equatorial islands, and, second, that maize was found by Captain Moresby in cultivation with yams, sweet

* Even the cosmopolitan tropical weeds are worthy of careful study from this standpoint. After excluding aquatic, swamp-land and strand species, Seeman found 64 genuine weeds in Fiji, of which 48 were common to America, while only 16 were held to be Old World species.

potatoes and sugar-cane in eastern New Guinea and the adjacent islands, among Polynesian tribes who had never been visited by Europeans and who were ignorant of salt, iron and rice. Tobacco was also known among many primitive peoples of the Orient before they came in contact with Europeans, though these and many similar facts have remained obscure because the European discoveries of the East and the West Indies were practically simultaneous. Moreover, nearly a century elapsed between the discovery of America and the realization that it was indeed a new world and not merely an eastward prolongation of Asia, so that the community of food plants did not at first appear remarkable.

The Agriculture of Ancient America.

The most important food-plants of the Polynesians were seven in number, the taro, yam,* sweet potato, sugar-cane, banana, breadfruit and cocoanut, of which six, or all except the breadfruit, existed in pre-Spanish America, and of these, five, or all except the cocoanut, were propagated only from cuttings.

From the botanical standpoint the breadfruit is as distinctly Asiatic as the cocoanut is American, but although many seedless varieties of the breadfruit were distributed among the eastern archipelagos of Polynesia, these did not reach America until introduced by Captain Bligh in 1793, while the cocoanut must have crossed the Pacific thousands of years before, in order to give time for the development of the numerous and very distinct varieties cultivated in the Malay region. Except with the banana, botany gives much evidence for and none against the new world origin of the food plants shared by ancient America with Polynesia and the tropics of the old world, though few of them are known under conditions which warrant a belief that they now exist anywhere in a truly wild state. The partial or complete seedlessness attained by several of the important species also indicates dependence upon human assistance in propagation for a very long period of time, and precludes all rational doubt that their wide dissemination was accomplished through the direct agency of primitive man.

Ethnologists will not deny that in the old world this distribution was the work of the ancestors of the Polynesians, who have been traced from Hawaii and Easter Island to Madagascar, and even across the African Continent.† We have not, however, been provided with any explanation of the existence of these food plants in America, for it is

* Many species of true yams (*Dioscorea*) are cultivated, and the roots of numerous wild species are collected for food in various parts of the Tropics. The present reference is to *D. alata*, the most widely distributed of the domesticated species, and not known in the wild state.

† Frobenius, *Zeitsch. der Gesellsch. für Erdkunde zu Berlin*, Bd. 33, 1898. Report of the Smithsonian Institution for 1898, pp. 637–650.

now generally agreed that the tribes, languages and arts of the American Indians are of truly indigenous development, while it is held, on the other hand, that the Polynesians migrated eastward from Asia, but without reaching the shores of America. That these two suppositions can not both be true is apparent as soon as it is known that there has been a transfer of numerous cultivated plants between Polynesia and America, and other agricultural facts enable us to judge between the inconsistent theories. Since it is reasonable to suppose that the food plants which the Polynesians shared with the tropical peoples of both continents were carried by them across the Pacific, it is also reasonable to seek the origin of these widely distributed species on the continent which gives evidence of the oldest and most extensive agricultural activity, and to the question in this form there can be but one answer. The agriculture of the old world tropics is adequately explainable by the supposition that it was brought by the Polynesians, since the root-crops of the Polynesians were also staples of the old world tropics. This proposition would not apply to America, where, in addition to the sweet potato, yams, yam-bean (*Pachyrhizus*) and taro, which crossed the Pacific, the aborigines also domesticated a long series of root-crops—*Manihot* (cassava), *Maranta* (arrowroot), *Calathea* (lleren), *Solanum* (Irish potato), *Xanthosoma* (several species), *Oxalis* (Oca), *Canna, Tropæolum, Ullucus, Arracacia, Sechium* and *Helianthus* (artichoke), all of considerable local importance.

The simplest of cultural methods, propagation from cuttings, was applied to all these root-crops* and has been in use for so long a period that several of them have become seedless. With equal uniformity the distinctively old world root-crops are grown from seed. American root-crops belong to at least twelve natural families, and the only important old world addition to the series is the mustard family, a distinctly temperate group, the cultivated members of which have not been greatly modified in domestication, and are still known in the wild state.

This apparent superfluity of American root-crops is explainable by the fact that different plants were independently domesticated in different localities, which means also that conditions favorable to the development of agriculture were very general among the natives of America. That most of these plants are not known in the wild state testifies also

* *Sechium* is perhaps an exception, but the more varied and localized names of the root are an indication that this plant was first domesticated as a root-crop. It may also be noted that *Sechium* is peculiarly adapted for teaching the art of planting seeds, since the fruit does not decay, but remains alive and edible long after the contained seed has germinated and sent forth a new vine with its leaves and roots. (See 'The Chayote: A Tropical Vegetable,' Bulletin No. 28, Div. of Botany, U. S. Dept. of Agriculture.)

to the great antiquity of this agricultural tendency, while archeology gives equally vivid testimony to the same antiquity and diversity of the prehistoric civilizations of America. From the mounds of Ohio to the equally remarkable ruins of Patagonia, the American continents and islands are, as it were, dotted with remains of rudimentary civilizations which must have required centuries and millenniums to rise from surrounding savagery, culminate and perish. The constructive arts by which the existence of these vanished peoples is made known took the most diverse forms; some made mounds, some expended their energies upon huge carvings on high inaccessible rocks, some dug devious underground passages, some set up monoliths and carved statues, and some built massive pyramids, temples and tombs, while still others are known only from their pottery or their metal work. In civilization, as in agriculture, the tropics of America stand in striking contrast to those of the old world. Here men of the same race showed great diversity of plants and arts; there races are diverse, while arts and staple food-plants are relatively little varied. The early civilizations of the eastern world resembled some of the primitive cultures of America more than these resembled each other.

The American origin of agriculture is thus not doubtful, since not merely one, but several, agricultures originated in America. The same cannot be claimed for Asia and Africa, where only root-crops shared with America attained a wide distribution, an indication that they reached those continents before the uses of the similar indigenous plants had been discovered.

Poisonous Root-Crops.

The American habit of eating roots was not a simple and direct transition from the use of fruits, which are commonly supposed to have been the primitive food of man. The more important and the more ancient of the distinctively old world root-crops, onions, leeks, garlic, carrots, radishes and turnips, are eaten, or are at least edible, in the raw state, while in America there seems to be no indication that the natives used any of their root-crops in this way. Some of them, such as the sweet potato, the artichoke and the 'sweet cassava,' can be eaten raw, but throughout the tropics of America the Indians, like the Chinese, prefer everything cooked. This habit must have been adopted very far back to have made possible the obviously ancient domestication of *Manihot* (cassava), *Colocasia* (taro) and *Xanthosoma* (yautia), since the fleshy underground parts of these plants contain substances distinctly deleterious until disintegrated and rendered harmless by heat. The same may have been true of the sweet potato, since the fleshy roots of its uncultivated relatives are strongly purgative. Several of the yams, both wild and cultivated, are also poisonous in the raw state.

A culinary art which remained largely confined to the aborigines of tropical America and to the straight-haired races of the tropics of the old world is the making of starch or meal from roots which have been grated, soaked, washed or boiled with alkalies to destroy their poisonous properties. Separated from the sugars and other readily soluble substances which retain or absorb moisture, the starch of the taro, cassava, arrowroot, canna and other root-crops can be quickly and thoroughly dried, and will then keep indefinitely. In the absence of cereals this simple expedient might well be deemed an epoch-making discovery, since it rendered possible the accumulation of a permanent, readily transportable food supply, and thus protected man from the vicissitudes of the season and the chase. That the resulting economic difference appeared striking to the hunting tribes of Guiana is apparent in the name they gave to their agricultural neighbors, whom they called '*Arawacks*' or 'eaters of meal.'

Cassava in the raw state carries a deadly charge of prussic acid and begins to decay in a few hours after being taken from the ground, but properly prepared it furnishes the starch which keeps best, and which in the form of tapioca our civilization is tardily learning to appreciate as a wholesome delicacy. In view of its unpromising qualities when raw, cassava would seem not to have been the first root-crop from which meal was made, and yet it is used by many South American tribes* who plant nothing else except the so-called peach palm (*Guilielma*), which gives suggestive evidence of a cultivation much older than that of the date palm, since it is generally seedless, and it is not known in the wild state. The farinaceous fruits are made into meal and baked into cakes in the same manner as the cassava, to which resource is necessary during the months in which the single harvest of palm fruits is exhausted.

Cassava is, indeed, so distinctively the best, as well as the most generously and continuously productive of the tropical root-crops, that it could hardly have been known in the regions in which the others were domesticated. Ever since the Spanish conquest put an end to the isolation of the native peoples of tropical America the use of cassava has been slowly extending at the expense of similar crops; it has also found a footing in the Malay region and other parts of the East, though from present indications it may be thousands of years before its value will be properly appreciated. The slow extension of so desirable a

* Some of these tribes are extremely primitive and in the absence of all domestic implements grate their cassava on the exposed spiny roots of another native palm (*Iriartea exorhiza*). The Arawacks are similarly dependent upon still a third palm (*Mauritia*), from the pith of which they secure starch in a manner strongly suggestive of that used with the sago palm of the Malay region.

plant among the tropical peoples excludes also the suggestion of any recent introduction from Polynesia of the taro or other root-crops which the Pacific peoples shared with the American.

Indeed, it is not unreasonable to believe that the taro, like the closely similar aroids of the genus *Xanthosoma*, was domesticated somewhere about the shores of the Caribbean Sea, where it has a large variety of native names in contrast to the single designation applied to it by the Polynesians. In Porto Rico, where the highest aboriginal culture of the West Indies was attained,* four aroids had the same generic name, *yautia*, which was adopted by the Spanish settlers. Strangely enough it is only with the taro, *yautia malanga*, that the native specific term has been preserved, three species of *Xanthosoma* having now only Spanish adjectives, *yautia blanca*, *yautia amarilla* and *yautia palma*. Botanists have never expressed a doubt that the species of *Xanthosoma*, some of which are known only in cultivation, originated in the West Indies and the adjacent parts of South America, and as these seem to be preferred to the taro, we must either look upon the latter as also indigenous in the West Indies or explain its presence by a movement from the mainland analogous to that which could have carried the same taro and numerous other American plants into the Pacific. Taro seems to have been the only cultivated aroid of the region of Panama whence some ethnologists have derived the sea-faring cannibals, the Caribs. To believe that the taro furnished the suggestion for the utilization of the *Xanthosomas* and also for that of *Alocasia*, *Amorphophallus*, *Cyrtosperma* and other aroids indigenous to the East Indies, seems far less irrational than to suppose that the strange habit of eating these painfully unpalatable plants originated independently in numerous primitive communities.

From Root-Crops to Cereals.

While it is, of course, not certain that the preparation of the starchy root-crops constituted the first regular application of fire to vegetable food, it is apparent that meal-eaters would be in a much better position than fruit-eaters or meat-eaters to attack the final problem of primitive agriculture, the use of cereals. Without the winter protection which primitive man could not supply, the culture of cassava and other trop-

* Botanists have found that the native names of plants are more numerous and are used with more precision in Porto Rico than elsewhere in the West Indies. The common opinion that the aborigines of this island were exterminated by the Spaniards is evidently quite erroneous. In the mountainous interior district there are thousands of people who have no negro admixture and who are accordingly enumerated in the census as whites, but who are Spaniards only in language and in the wearing of cotton prints. Their agriculture, architecture and domestic economy show little foreign influence, and there is no reason for believing that these natives differ seriously from their pre-Columbian ancestors.

ical root-crops is confined to strictly tropical climates, so that increase of latitude and altitude would bring to starch-eating peoples the necessity of a change of food plants. Indeed, altitude seems to have played a larger part than latitude in this transformation which brought about the adoption by primitive American peoples of Indian corn, 'Irish' potato, arracacha, oca and other crops of the temperate plateaus of South America. Without reasonable doubt, maize is the oldest of cereals, and the large soft kernels which distinguish it from all other food-grasses are exactly the character which would render it easily available to the meal-eating aborigines of America, though it is not to be supposed that the wild progenitor of the Indian corn had any very close similarity to our cultivated plant. Moreover, everywhere in tropical America maize is still prepared by methods adapted to root-crops instead of as a cereal. The rough stone slab (metate) against which they had rubbed their cassava or other starch-producing roots was well suited to making paste from maize, softened by soaking in water with lime or ashes, and throughout tropical America it has remained in use to the present day. Among the tribes of the arid temperate regions where the tropical root-crops were excluded the metate was deepened into the mortar in which seeds too small to be collected or handled singly are also bruised into meal.

It is also not impossible that maize was the first plant to be grown by man from seed, a cultural method permitting much easier and more rapid distribution than had been practicable with the root-crops grown from cuttings and tubers. Like other species cultivated in the highlands of tropical America most varieties of maize do not thrive in moist equatorial regions of low elevations, so that it did not seriously supplant the root-crops, though having a far wider distribution than any other plant cultivated by the aborigines in pre-Spanish America. Nor did the utilization of maize mark the limit of cereal cultures in America, though no other small foodseed of the new world compares in popularity with rice, wheat, barley, rye and oats. Even in Mexico, the supposed home of maize, the seeds of *Amaranthus* and *Salvia* (Chia) attained considerable economic importance. In addition to their use as food the latter were made to furnish a demulcent drink and an edible oil valued as an unguent and in applying pigments, a series of functions closely parallel to those of sesame, perhaps the most ancient of old world herbaceous seed-crops. Wild seeds of many kinds were collected by the Indians of the United States and Mexico, including wild rice (*Zizania*) and *Uniola,* another rice-like, aquatic grass of the shallow shore-water of the Gulf of California. In Chili there existed also several incipient cultures of small-seeded plants, such as *Madia,* while the people of the bleak plateaus of Peru and Bolivia had developed a unique

cereal crop from a pigweed (*Chenopodium quinoa*), another of many evidences of a very general tendency to agricultural civilization in ancient America.

As long recognized by historians and ethnologists, maize was the most important factor in the material progress of ancient America, and the American civilizations remained on a much more strictly agricultural basis than those of the old world, a fact not without practical significance to modern agriculture since it undoubtedly conduced to the more careful selection and improvement of the many valuable plants which we owe to the ancient peoples of America. Subordinate only to maize from the agricultural standpoint was the domestication of the beans, while the materials for a developed culinary art and a varied and wholesome diet were furnished by a variety of minor products like the Cayenne pepper, the tomato, the tree tomato (*Cyphomandra*), the pineapple, several species of the strawberry tomato (*Physalis*), the pawpaw (*Carica*), the granadilla (*Passiflora quadrangularis*), the gourd, the squash and the peanut. American fruit trees, such as the custard apple and related species of *Anona,* the alligator pear (*Persea*), the sapodilla, *Mammeas* and *Lucumas* afford refreshing acids, beverages, relishes or salads, but do not furnish substantial food like the banana. Contrary to the opinion of De Candolle there is every probability that the banana reached America from the west long before the arrival of the Spaniards, but it evidently did not come until after the agriculture and cultivated plants of America had spread into the Pacific.

No Pastoral Period.

The agricultural history of the Malays, Chinese, Japanese, and other Mongoloid peoples of the western shores of the Pacific, is exactly that of the American races, and differs fundamentally from that of the peoples of western Asia and the Mediterranean region in giving no indications of a primitive pastoral stage which so many writers have taken to be man's first step from savagery toward civilization. The straight-haired peoples made, however, early and vigorous use of a large number of Asiatic plants and showed skill in agriculture and irrigation equaled in prehistoric times only along the western coasts of America, among the congeries of primitive civilizations commonly not distinguished from the terminal members of the series, the Peruvians and Mexicans.

That the Aztec and Inca empires were comparatively recent organizations has caused many ethnological writers to forget that they incorporated much more ancient culture. For centuries still unnumbered the Andean region of South America supported crowded populations. On the western slopes of Peru every inch of irrigable land was cultivated,

houses and towns being relegated to waste places. The temperate food plants of Peru and China are all apparently indigenous to their respective continents. They testify to the independent development of the temperate agricultures of the two regions, but it seems certain that both were the successors of more tropical starch-eating populations, parts of which had been crowded back to the relatively inhospitable plateaus of Peru and Bolivia, and to the bleak plains of northern China, where the primitive tropical root-crops were, of necessity, replaced by more hardy indigenous species. The Chibcha people of the interior of Colombia attained a considerable degree of advancement without adopting a single domestic animal. The Peruvians and Chinese learned to use beasts of burden and animal fibers and skins, but their pastoral efforts were merely incidental to agriculture; they remained essentially vegetarians, eating little meat, and never taking up the use of milk.

The Domestication of the Banana.

In further support of the suggestion that the use of the starch-producing root-crops is a distinctively American development of primitive agriculture is the fact that the tropics of the old world contributed no important cultivated plant of this class, and none which gives evidence of long domestication. On the other hand, such regions as Madagascar and East Africa, where Polynesians are now supposed by ethnologists to have settled in 'remote prehistoric times,' continued the culture and differentiation of the varieties of the taro and the sweet potato, and were agriculturally mere outposts of the American tropics.

The presence of the banana might be thought to explain the relatively small importance of root-crops in the old world, since it furnishes with far less effort of cultivation and preparation a highly nutritious and palatable food. It appears, however, that the use of root-crops must have preceded the domestication of the banana, for although the seed-bearing wild bananas are utterly worthless as fruits and hence would not have been domesticated as such, nevertheless more species of them than of any other genus of food plants were brought into cultivation. The clue to this paradox is afforded by the fact that bananas are still cultivated as root crops in the old world tropics, particularly in New Caledonia and Abyssinia.*

* The suggestion that the primitive culture race which domesticated the banana came from America also receives definite support from the fact that an American plant (*Heliconia bihai*), somewhat similar to the banana but without an edible fruit, reached the islands of the Pacific in prehistoric times. Though no longer cultivated by the Polynesians, it has become established in the mountains of Samoa and in many of the more western archipelagos. In New Caledonia the tough leaves are still woven into hats, but the *Pandanus*, native in the Malay region, affords a better material for general purposes and has dis-

That the varieties used for this purpose are as old or older than those grown for fruit is indicated by the fact that, like the sweet potato, taro and sugar-cane, they seldom produce flowers. Furthermore, among all savage tribes the varieties valued by civilized peoples as fruits are relatively little used, far greater popularity being enjoyed by the so-called 'plantains,' not edible in the raw state, even when ripe, though nearly always cooked and eaten while still immature, or before the starch has changed to sugar. They are also in many countries dried and made into a meal or flour often compared to arrowroot.

In dietary and culinary senses the breadfruit also is as much a vegetable as the taro or the sweet potato; as a fruit it would be no more likely to be domesticated than its distant relative the Osage orange. The farinaceous character of the breadfruit also probably explains its relatively greater importance among the Polynesians than in its original Malayan home, as shown by the propagation of numerous seedless varieties. The popularity of the breadfruit among the Polynesians was further extended by the discovery that the fruits could be stored in covered pits, the prototypes of the modern silo.

If the domestication of the banana is to be ascribed to cultivators of root-crops, the same reasoning applies with even greater propriety to cereals. Tribes accustomed to subsist upon mangoes, dates, figs or similar fruits which require no grating, grinding or cooking, and are eaten alone and not with meat, would not develop the food habits and culinary arts necessary to equip primitive man for utilizing the cereals.

Wild bananas and their botanical relatives are natives of the rocky slopes of mountainous regions of the moist tropics where shrubs and trees prevent the growth of ordinary herbaceous vegetation. The commencement of the culture of cereals by fruit-eating natives of such forest-covered regions is obviously improbable, but such an undertaking would be a comparatively easy transition for the meal-eating cultivators of root-crops, since the grasses and other plants domesticated for their seeds are exactly those which flourish in cleared ground and are prompt to take advantage of the cultural efforts intended for other crops. Thus, the Japanese have by selection secured a useful cereal from the common barnyard-grass (*Panicum crus-galli*) just as they have made a root-crop of the burdock. Accordingly, we should look to some taro-growing tribe of southeastern Asia as the probable domesticators of rice, and to other cultivators of root-crops for similar services in taking up the somewhat less tropical cereals, sesame and Guinea corn. That root-crops preceded cereals in America was inferred above partly from the

placed *Heliconia* in cultivation among the Polynesians. In the time of Oviedo the natives of the West Indies made hats, mats, baskets and thatch from the leaves of *Heliconia*, and the starchy rootstocks were eaten.

fact that root-crops were not there grown from seeds; and there is a corresponding indication that the knowledge of cereals preceded the domestication of the seed-grown temperate root-crops of the old world, since none of these is anywhere dried, made into starch, or otherwise prepared for storage as the basis of a permanent food-supply of primitive tribes.

That the fruit-eating aborigines of the old world were not equipped for undertaking the use of cereals is further shown by the fact that those who left the moist tropics for the subtropical and temperate regions of Western Asia, North Africa and Europe did not resort, as in America, to the culture of more hardy root crops and cereals, but became pastoral nomads, dependent upon the milk and flesh of their herds, supplemented by such honey, wild fruits and other edible plants as they might encounter in searching for pasture. Dates, figs and other fruit trees might receive some attention from such wanderers, but the more successful they might become as shepherds the less likely they would be to take up the planting of cereals or of other herbaceous crops, which in the absence of fences would be appropriated by their animals before the owners could make even an initial experiment. It is accordingly significant that the origin of the agricultures and civilizations of the valleys of the Nile and Euphrates is no longer sought by ethnologists with Semitic shepherds or more northern peoples, but with a seafaring race which has been traced to southern Arabia, and whose language has been found to have analogies with the ancient Polynesian tongue of Madagascar.

Summary.

With the exception of the banana, the cultivated plants which were shared with America by the natives of the islands of the Pacific and of the old world tropics appear to be of American origin, and the wide distribution of these plants in the east and the relatively recent domestication of the old world root crops and cereals accord with the suggestion that the agricultural skill and compact social organization of a primitive American culture race were transferred to southern Asia during the movements of conquest and colonization which spread the Malayo-Polynesian linguistic stock from Hawaii and Easter Island to Madagascar and southern Arabia, but long anterior to existing peoples or languages. The cocoanut which affords so direct an intimation of American origin has already explained the failure of those who have attempted to demonstrate identity of languages, customs and arts on the two sides of the Pacific, but also condemns the equally erroneous attitude of others who refuse, in the absence of such identity, to accept the countless trans-Pacific similarities as indications of affinity or common origin.

The distribution and uses of the tropical cultivated plants support the belief of ethnologists in the truly indigenous character of the peoples, agricultures and civilizations of the new world, but they also testify to a very early colonization of the islands of the Pacific and Indian oceans from tropical America. The comparative deficiency of the western continent in fruits and animals suitable for food was compensated by numerous starchy root-crops. The primitive culture peoples of the tropical regions of ancient America were accustomed to the cooking, grinding, and storing of vegetable food, and were thus prepared to appreciate and utilize the cereals by agricultural experience lacking among the fruit-eating aborigines of the old world, who developed instead the arts of the chase, the domestication of animals, and the use of milk. But fruit, meat and milk do not complete the agricultural series, and do not include its essential members, since civilizations have nowhere developed without the assistance of the farinaceous root-crops and cereals, the use and cultivation of which are habits acquired by primitive man in America and carried in remote times westward across the Pacific, together with the social organization and constructive arts which appear only in settled communities supported by the tillage of the soil.

By means of agricultural facts it is possible thus to choose between the rival theories of the ethnologists, and in addition to gain a suggestion of the history of agriculture among primitive peoples. If we may not know where man first began to encourage the growth of the plants which furnished his food, we are not without numerous indications that agriculture proper, together with the agricultural organization of human society which lay behind modern civilization, originated in America and has now completed the circuit of the globe.

MENTAL AND MORAL HEREDITY IN ROYALTY. III.

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Evidence from the Romanhofs in Russia Down to Peter III.

From Feodor Romanhof (1550–1633), to Peter III. (1728–62), includes six generations and twenty-one persons in the direct family. These twenty-one show the most remarkable variation in character and abilities.

The first one to be considered, Feodor, was the greatest man in Russia in his day, and it was owing to *his* abilities and virtues that his son, Michael, was placed on the throne. Michael was prudent, mild and virtuous, married a peasant woman of the same character and was the father of Alexis, who in his time was very much like his parents. Alexis married twice, both queens being beautiful peasant girls. The czars at this time chose their wives from a large number of their subjects. All the charming peasant girls were brought to the court for their sovereign's inspection, the most beautiful being chosen and made legal queen.

From both of these unions came epileptic children. It seems impossible to trace the origin of this famous neurosis in the Romanhofs since it probably arose in the obscure stock back of Alexis. From Alexis' first marriage were produced Feodor, imbecile; Sophia, extraordinary force of will, ambition and high abilities; and Ivan, imbecile and epileptic. From the second marriage came Peter the Great, extraordinary will and capacity, but violent and epileptic; and several other children in no way remarkable. The genius of Peter the Great and Sophia may have been a reversion to Feodor, their great-grandparent, or it may have been a manifestation of the neurosis as Lombroso would say. On account of the very same ability already in the family as well as the evident neurosis, it does not seem necessary to consider them evidences of the insanity of genius, since the genius may have struck them from one source and the insanity from another. Those who consider the tyranny of the Russian czars a result of absolutism of the rulers should remember that just prior to the appearance of the neurosis there were four sovereigns who were in every way wise, mild and virtuous. Also the 'Age of Absolutism' in Denmark produced mild and good-natured rulers.

Now from this time on we find among the remaining eighteen who appear in the next three generations, six who have extremely bad char-

acters; three of these are children, two are grandchildren and one is a great-grandchild of Peter the Great. Thus in this arrangement we see the principle of heredity which calls for a closer resemblance among those more closely related in kin.

Of Ivan's children, Catharine was as good as the Empress Anne was inconsistent, vindictive, cruel, passionate and sentimental. Catharine married average stock, but her daughter, Anne, was passionate, indolent, capricious and weak. Anne married the excellent but mediocre Anton Ulric, of Brunswick, which family we have already seen to be full of virtue and literary tastes, so that the next generation brings one parent and three grandparents free from the taint.

We now get just what we might expect, in spite of the fact that the five children were all taken when infants and for political reasons imprisoned for thirty-six years. Ivan the eldest was almost an imbecile and showed occasional symptoms of insanity.* This imbecility might be attributed to the imprisonment, which was extremely severe, but the other four children help us out. The following is taken from Coxe, a very accurate historian:

> Elizabeth, the youngest sister, was a woman of high spirit and elegant manners. On being released she wrote a letter of thanks to the empress so well expressed as to excite admiration how she could have obtained sufficient instruction during her long confinement.
>
> The other children were mediocre and in no way peculiar. "They amuse themselves with reading, playing billiards and cards, riding and walking. They walk much about the town and in the environs, and drive out in carriages; the princes frequently ride and particularly Alexis, who is very fond of that exercise, and said to be an expert. They not infrequently pay visits in the country and dine with the neighboring families."†

Thus among five children exposed to a very unusual environment from infancy we find a result showing little influence other than should be expected from heredity. Three were mediocre representing the majority of the strain, one was an imbecile, corresponding to the combined influence of his mother and great-grandfather, Ivan, and one was spirited and cultivated in spite of it all, and rose very nearly as high as any of the immediate ancestors. Of course such remarkable circumstances must have modified the characters of the four normal ones, at least to some noteworthy extent, such as raising one of the sons above the absolute mediocrity in which we find them; but I do contend that even these deviate very little from what is to be expected from the principles of heredity as we usually expect them to act.

Alexis, Peter the Great's son by his first wife, Eudoria Lapookin, was a very poor specimen.

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* Coxe, 'Travels,' III., p. 51.

† Coxe, 'Travels,' V., p. 19.

Never was the birth of any prince more unfortunate to himself, to his parents and to his country. All persons however join in condemning the imprudence and obstinacy of Alexis which seems to have warped his judgment and at times to have transported him to a degree of insanity. Alexis was extremely dissolute and preferred the company of the lower classes. When twenty-six, worn out by continual drunkenness, he demanded permission to retire to a convent, but changed his mind and escaped to Vienna.

He was retaken and tried. He died soon after, probably murdered by his father's orders, though some historians contend he died, as Peter claimed he did, by an apoplectic fit.

By Peter's second marriage with Catharine he had two daughters, Elizabeth and Anne. They were as different as possible. Elizabeth, the notorious empress, was very inconsistent, being indolent, dissolute, cruel and pious.* Anne, on the contrary, was serious-minded, cultivated and virtuous.† The latter married Charles Frederick, Duke of Holstein, an inferior sort of man of undistinguished parentage, and the only son, Peter III., was as bad as the worst of them, being weak, dissolute, violent and headstrong. Alexis, the imbecile son of Peter the Great, married Charlotte, an 'angelic' daughter of the good House of Brunswick already referred to, and by this marriage we see two children, one good and one bad. Natalia, the daughter, was sweet tempered, remarkably bright and energetic, while Peter, the son, who became Peter II., in spite of the best education, gave up all study and political work and confined himself to hunting and shooting. He had a 'somewhat unstable mind,' but his character showed none of the cruelty and degeneracy of some of the others of the family. Peter III. married Catherine of Anhalt-Zerbst, who became the notorious empress Catherine II. As we do not know who was the father of Paul, owing to the licentiousness of Catherine, the remaining division of the so-called Romanhofs down to the present day had best be studied as another group.

The great variation in the characters of the early Romanhofs is better explained by the presence of the neurosis than by any other cause, since this has been shown to account for it.

If we consider the rudeness of the times to be the cause we can not see just why the first three of the Czars, Feodor, Michel and Alexis, were so prudent, mild and virtuous, or why the subsequent neurosis appears more frequently in those closely related to the height of its manifestation in the generation of Peter the Great. In modern Spain a condition similar from the heredity standpoint can be studied under several different environments in no way like that of early Russia, yet the variation in character in the royalty of modern Spain is quite

* Lippincott and Coxe, 'Travels,' II., pp. 302–306.

† Bruce's 'Memoirs,' pp. 100–197.

as remarkable as that just considered. In Spain it is related to an inherited mental unbalance in just the same way as in Russia.

Evidence from the House of Montmorency.

Since the family of Nassau Orange perpetuated itself by aid of the House of Coligny and since the Collignys, Condés and Montmorencys intermarried freely, these three families may be considered next and treated as one group under the three separate headings.

The pages of Betham's 'Genealogy of the Sovereigns of the World' (London, 1795) contain from Eberhard Montmorency contemporary with Hugh Capet to Anne, Duke of Montmorency, the great Constable of France (1493–1567), 107 names covering a period of eighteen generations. During the later sixteen of these generations, the family held exceedingly high social position and were lords of Montmorency, Laval, Montfort, etc. There were among this 107 a considerable number of persons of local influence, constables and marshals of France, but the names of two alone of this large number, the product of eighteen generations, have come down to us as distinguished historical characters.

These are Mathew I., Constable, died in 1151, and Mathew II., called ' The Great,' died 1230. They were grandfather and grandson. The next great Montmorency was Anne, Constable of France (1493–1567) (8). "He was a brave but ferocious warrior, was totally illiterate, and yet through his natural talent and the experience of a long life, he was an able statesman and counsellor." None of the immediate ancestry of Anne appears to have been famous, as the two Mathews are many generations back; therefore the inherited talents of Anne must be considered a new variation.

Now comes another little region of great names: Anne's second son, Henry I., Duke of Montmorency, was a distinguished legislator (8), being the only one of seven mature children to reach high fame; the general average of the fraternity shows the reversion to the mean.

Henry II., the representative of the next generation, was rather more distinguished than his father. He was the only son to reach maturity. His sister, Charlotte, who married Henry II., Prince of Condé, and was the mother of the Great Condé, has remained famous all these years, but rather for her extreme beauty and strength of character than for purely intellectual qualities. There were two other sisters not distinguished. Henry left no children, so the male line ends here.

Not only is this house, as is well known, an instance of heredity, but its closer analysis strengthens this view even more, and the six most famous ones fall in two little groups far removed from each other; and comparing the percentages of geniuses with the sizes of

the family, we see that it does not prove too much. The first eighteen generations show a perfectly natural result from the influences of heredity. The last three generations giving four big names among eighteen are also in line with the expected, since both Anne and his most distinguished son, Henry, had large families, these great ones being a select few out of many. It will be seen later that the great descendants of the Montmorencys, who bore the name of Condé, traced their lineage from the great names among the Montmorencys, not from the mediocre.

Condé.

This high wave of Montmorency had probably a great deal to do with making the name of Condé so well known, since its greatest personages were the children of both families. The male line of Condé is traced through the lines of Marche and Vendome back to Robert, Count of Clermont, Lord of Bourbon (died 1317) and son of Louis IX., prince of France. From Robert to Louis I. Prince of Condé (died 1569), includes in the direct line forty-four adult names, covers a period of two and a half centuries and includes nine generations. During the first of these generations not a single one, as Count of Vendome, Duke of Bourbon, or the possessor of any other high title ever distinguish himself sufficiently to be even mentioned by 'Lippincott's Dictionary.' During all this time one also notices no illustrious name on the maternal side, so this is all to be expected.

Now in the ninth generation appears Louis, the first distinguished Condé, the eighth of ten mature brothers and sisters. His oldest brother, Anthony de Bourbon, King of Navarre, is famous, but ranks far from the great. He was a weak and irresolute prince, who died in 1562 'detested by the protestants whom he had deserted and little regretted by the catholics.'* The second brother, Charles, was one of the chiefs of the catholic league and receives a few lines in 'Lippincott.' The other children were not heard from.

It does not appear clear where Louis's talents arose since none of his immediate ancestors were remarkable, nor was his marriage calculated to perpetuate any greatness he might have inherited, since his wife, Eleonoro, was a daughter of Charles, Count of Ponce, a family of no distinction. He had three sons, one of whom was Henry I., Prince of Condé. He was 'liberal, gracious and eloquent and promised to be as great a captain as his father.'† Only two of the eight other children reached maturity. These two held high titles and presumably had equal opportunities, but left no great names behind them. Now supposing Henry I. to have inherited all the talents of his father, and

* Rose, 'Biographical Dictionary.'

† Brantome, 'Vies des hommes illustres.'

that he was the only one to so inherit them, the next generation would have just as much chance to receive the birthright of the Condé's as his own generation had. There were but two children, and it is not asking too much from heredity if we believe that one of these two again shows the family strength by the same cause, since a father, grandfather and great grandfather are worth about 33 per cent., and we add to this one distinguished ancestor on the maternal side, since the mother of the children of the next generation was a granddaughter of Anne, the great Constable Montmorency, referred to above as the beginning of the second celebrity of the Montmorency family. This one to follow in the footsteps of his father was Henry II. of Condé, whose record, however, was not so illustrious as that of some of those who had gone before.

We now come to one of the greatest 'fraternities' in point of average to be found in all modern royalty, at least among those fraternities that contain as many as three children. Here we find two out of three in about the highest intellectual rank. Louis II., the 'Great Condé' and his sister Anne, Duchess de Longeville, certainly belong in 10. The third was Armand, Prince of Condé, famous but not praised either for character or intellect.* Can we account for these strictly by heredity? If these three children had arrived without any other influence than the House of Condé, it would be evidence against heredity, since before the fourth generation reversion to the mean would be called for; but it certainly is significant to note that this most brilliant fraternity of all is also backed by about the most brilliant pedigree of all royalty since Henry II. of Condé married Charlotte, daughter of Henry I. of Montmorency. She was noted for her beauty, strength of character and fascinating qualities. Henry I. was the center of the Montmorency genius. Thus the greatest of the Condés occur where we should most expect them, just at the junction of the two great streams.

The subsequent history of Condé is one of decline. Is there any infusion of bad blood sufficient to account for it aside from the external circumstances in which they lived? Louis II., the Great Condé, married Clemence, a daughter of Urban de Maillé de Brézé and a niece of Cardinal Richelieu. Maillé de Brézé was marshal of France, so it might seem at first sight as if this would be a case where we might expect a perpetuation of genius. But in looking more carefully we get the following idea of the character of the marshal, which throws no optimistic light on the rest of the members of the family. Maillé de Brézé was made Marshal of France in 1632, and left his command in Holland in anger saying that he *n'etait point bête du compagne.* In 1636 he was given the government of Anjou, where he showed himself '*bizarre* and tyrannical.' He gave but little proof of military talent.

* 'Encyclopædia Britannica.'

Lenet said that he was under the possession of a woman (la Dervois), the widow of one of his valets, ugly but of quick and forceful mind, who governed his entire fortunes up to the last breath of his life. Cardinal de Retz pictured him as extravagant, but sufficiently to the taste of the king for him to permit the marshals' tirades against the greatest personages of the court. So much for the father; the mother, Nicole, was insane, and the daughter, Clementia, was woman '*energetique vaillante et même cruelle.*'*

The Great Condé had but one child. If he had been the father of several, we might expect some to have been very brilliant and perhaps escape the taint. This one son was Henri Jules. Eight lines are devoted to him in 'Lippincott's' and read as follows:

Condé de Henri (Jules de Bourbon), Prince, the only son of the Great Condé, was born in 1643. He distinguished himself at the siege of Tournay in 1665, and in 1674 took part in the battle of Seneffe, where he is said to have saved his father's life. Saint-Simon gives a just but most favorable view of his character. Towards the end of his life he became insane and fancied himself a dead man. Died in 1709.

Brilliancy, bad character and congenital insanity was then united with mediocrity, since the mother of the next generation was from an undistinguished branch of the Palatine House and mother's family, Nevers, is also ' obscure ' at this point.

Of the four adult children of Henri Jules, Anne Louisa, Duchess of Maine, alone has left a fame that has come down to us.

She had more than an ordinary share of the pride of birth by which that branch of the Bourbons was distinguished. She was highly educated and a great patroness of literature and art. Most of her life was spent in her beautiful mansion at Sceaux, surrounded by men most eminent for genius and learning. It was she who first patronized the muse of Voltaire.†

The intellectual qualities being the interesting thing to trace in the family of Condé, nothing further need be said save that the remaining nine showed no marked genius. The five in the next generation exhibited two instances of *extreme cruelty*. These were Louis IV., Prince of Condé, and his brother Charles, Count de Charlais.

Bad as the Duke de Bourbon was his brother the Count de Charlais was infinitely worse. He excited public execration by acts of such ferocious atrocity that they seem to belong to the worst tyrants of antiquity. Like all the nobles who had been educated under the regency he had abandoned himself to the wildest and most profligate debauchery which however did not satisfy him unless it was accompanied by the most savage cruelty. He murdered one of his servants whose wife, fondly attached to her husband, refused to receive his addresses. He fired at the slaters employed on the tops of houses and when he brought down one of his human game he hastened to gratify himself by watching his last agonies.‡

* Jacobi, 'Selection chez les aristocrats,' p. 414.

† Taylor, 'Mémoires Orléans,' I., p. 211.

‡ Taylor, 'Mémoires Orléans,' I., p. 383.

We notice that the writer refers to his having been educated like the other youths of the day in the debauching school of the regency, but does not make mention of the fact that he was a grandson of the mad Henri Jules.

The remaining generations had but one, two, and one children respectively. Since Louis IV., Prince of Condé, was of little account, and the remaining pedigrees contain Hesse, Rheinfels, Soubises and Orleans without bringing in intellectual distinction, as far as I know, there appears to be nothing against heredity in the closing chapter of the house. In fact the neurosis appears to have been eliminated through the principle of regression, and we find the last members of the house rather fine heroic types, though not like their Condé ancestors, capable of grappling with difficult conditions. The last of the line, Louis Anthony Henri, Duke d' Enghien, was executed in March, 1804, an act that is commonly regarded as one of the worst stains on the character of Napoleon.

THE COMPETITION OF THE UNITED STATES WITH THE UNITED KINGDOM.

By JOHN WADDELL, D.Sc., Ph.D.,
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IN the *Allgemeine Zeitung* of Munich, Dr. Alex. von Peez says, 'Slowly has England grown commercially, more rapidly has Germany risen after gaining political unity and establishing the protective system, but like a storm is the forward movement of the United States.'

In the ten years before 1897 the exports of manufactured articles averaged $163,000,000 annually; in 1898 the value was, according to the statistical abstract, $290,697,354; in 1899 it was $339,592,146, and in 1900 $433,851,756. This, be it noted, is the value of the *manufactured* articles, and does not include grain and agricultural products. The total sales of the United States to foreign countries amounted in 1900 to the tremendous total of nearly $1,500,000,000. In 1901 the exports in manufactures had decreased a little, being only $412,155,066, or about five per cent. less than in the preceding year; but this decrease is due apparently to a depressed state of trade in Europe during the last year—the general exports from Britain were also less in 1901 than in 1900.

The immense growth in the export of manufactures during late years is partly due perhaps to greater prosperity throughout the world, but since other nations, England, Germany and France, are not increasing to anything like the same amount, American competition is evidently becoming more prominent and distinct. The United States has a far greater share of the world's trade than she had ten years ago.

America's competition with the world is not confined to exports; the competition is also within her own borders and does not show in international trade. The United States now manufactures for her own consumption many things that formerly she imported from abroad. In many departments she has hitherto just been able to keep up with her own growth in consumption, having little left over for export. But in these departments she now threatens to invade the world.

Coal is an essential for a manufacturing nation. In 1896 the United States produced one hundred and sixty-seven million tons of coal, in 1900 she produced two hundred and sixty-eight millions. In that time the importation of coal increased nearly half a million tons, but the export increased four million tons. The total export of bituminous

and anthracite coal is now almost eight million tons, and, though this is small as compared with the home consumption, yet the export is likely to increase more rapidly, and a leading ironmaster in Germany predicts that in ten or fifteen years America will supply all the Mediterranean coast with coal and iron. He says that cheap production and transport will be the chief factors and will more than counterbalance the nearness of Britain. A few years ago Britain led as a coal producer, but now the United Kingdom is surpassed by the United States. In 1900 Britain produced two hundred and twenty-five million tons of coal, in 1901 she produced two hundred and nineteen million tons only. This difference of six million tons is almost exactly equal to the excess of exports over imports of coal in the United States.

An industry of very rapid growth in the United States is that of cement. There are two large and important classes of cements, called natural cement and Portland cement. In the United States natural cements are still produced in greatest amount, but the growth in output of Portland cement has been very rapid, and Portland cement bids fair soon to surpass natural cement in quantity. Not many years ago nearly all the Portland cement was brought from England, American Portland cement being considered inferior; but now by the introduction of rotary kilns and other improvements it is claimed that American Portland cement is made at least equal to and probably better than English cement.

The production of natural and Portland cement was in 1896, 9,510,355 barrels; in 1900 it was 20,486,274 barrels. This tremendous growth is due to the greatly extended use of cement in buildings and pavements and in structural works of many kinds in which stone was formerly used. This growth in consumption has not been accompanied by a growth in importation. On the contrary, the imports have declined to a slight extent, being in 1896 3,558,166 barrels, and in 1900 3,182,245 barrels. The export is small, but there is an increase from 87,910 barrels in 1896 to 186,586 barrels in 1900. This means that the cement factories have been able to keep up with the growth in the demand at home and have had a slight surplus.

The soda industry is one of the most important chemical industries, and in it England was for a long time supreme and America imported largely from her. Now, however, the importation is small, America providing her own soda to a great extent. In 1896 the soda imported was 86,991 tons, in 1900 it was 33,482. Common salt is the starting point for the manufacture of soda, and it is used for many other purposes as well. The world's consumption of salt has grown during the last twenty years, but Britain's output has fallen off. This appears to be largely due to American competition. In 1880 the United Kingdom produced nearly 2,700,000 tons of salt and the United States 800,000

tons. In 1889 the United Kingdom produced 1,950,000 tons and the United States 2,400,000 tons, which amount was increased in 1900 to 2,650,000 tons, so that now the United States occupies the position held by Britain in 1880.

The growth of the iron and steel industry in the United States is phenomenal. In 1901 the production of pig iron was 13,789,242 metric tons, as opposed to 13,620,703 metric tons in 1900. The metric ton is about a tenth larger than the ordinary ton, so that over fifteen million tons of two thousand pounds each was the output of pig iron in the United States. In 1882 the production was only 4,144,254 tons, of which approximately 0.15 per cent., was exported; of the 13,789,242 tons produced in 1901, the export amounted to 255,253 tons, or nearly two per cent. On the other hand, the import in 1882 was 496,045 tons, which was 10.65 per cent. of the total consumed, while the import in 1901 was only 39,325 tons, or 0.29 per cent. of the total consumption. In England, however, the importation of pig iron has increased from 1896 when it was 108,152 tons, to 1900 when it was 184,049 tons. The increase during the same time in steel imported into Britain is even more noticeable; the import of unwrought steel growing from 17,771 tons to 182,210 tons. The total exports of Britain in iron and steel are of course enormous, although the United Kingdom does not produce so much as the United States. There is not so much local consumption, and a large quantity is exported, the amount being in 1900 3,602,083 tons, a trifle less than the 3,607,204 tons exported in 1896. Britain's output of Bessemer steel was greatest in 1882, when it amounted to 1,125,785 tons; the present output of the United States is more than double that figure. It may be noted that Bessemer steel is largely used for rails, and the growth of railroads is now much greater in this country than in Britain.

Perhaps in nothing has the competition of the United States with the United Kingdom been more conspicuous than in tin plate. The use of tin plate has grown tremendously, owing to the growth of the canning industry, canned meats, canned fish, canned fruits and canned vegetables being now common where formerly they were rare.

The imports of tin plate from England were in 1869 over one hundred and eighty-one million pounds, and from 1884 to 1894 the yearly average was about five hundred millions, with the exception of 1891, when the remarkable figure of 1,036 million pounds was reached. But in 1901 the imports were one hundred and eighteen million pounds, a figure considerably less than in 1869. The value has decreased even more than the quantity, for in 1869 the value was $8,767,381, and in 1901 it was $3,770,062. To this extent has Britain lost in her trade in tin plate with this country. As against the decline in importation is the growth in production in the United States. In 1892 the produc-

tion in America was fourteen million pounds, in 1900 it was six hundred and seventy-eight million pounds, or in eight years the increase in output has grown more than forty-eight times. Tin plate has actually been landed in considerable quantity at Cardiff, the original home of the industry.

The figures given above for iron and steel refer to the unmanufactured product; in machinery and other articles manufactured from iron, the United States competes keenly with the United Kingdom. In connection with iron and steel may be mentioned the competition which America has offered in bridge building and similar work. England has till very lately had a practical monopoly of railway building in most of the British colonies. But the Atbara bridge in the Soudan was constructed by America, the lowest British tender being £15, 15s. (or $76.50) a ton, whereas the American tender was £10, 13s. 6d. (or $51.60) a ton. The British contract was for twenty-six weeks, the American for only fourteen. Afterwards came the construction of the Gokteik Viaduct in Burma, which was completed by an American firm in twelve months, and is the wonder of British engineers. The American tender was for fifteen pounds a ton, the lowest British tender was for twenty-six pounds ten shillings a ton, and the time required was three years. The Ugandy Viaduct is another instance in which the American tender was twenty per cent. lower than the British, and the time required slightly more than one third.

In rolling stock for railroads, American competition is likewise felt. New Zealand has taken locomotives from America, so has Cape Colony, which not long since placed a million pounds worth of orders including twenty-nine locomotives, in this country. Even the Midland Railway Company in England in 1898 ordered twenty locomotives from America. The Sanyo Company in Japan has been using American locomotives for six years and has lately ordered more from America, but not from Britain. They have already thirty-three American and twenty-four English engines. They say that the American engines are more quickly provided and cost only two thirds as much. It is said that the American design is the better, though it is admitted that the British workmanship is superior. The English boilers are more carefully riveted and are less liable to leak. The American wheels are, however, said to have better tires and to last longer.

As an example of how American machinery is being introduced into England, the experience of the firm of Messrs. Charles Churchill & Co. in London may be cited. Thirty-five years ago they commenced to introduce American machinery into Britain and met with many discouragements, but during the last five years they have sold four million dollars' worth of machinery. The business of the past year has been

the largest they have had, and it promises to be still better during the coming year.

The competition of the United States has not been confined to iron goods, to locomotives, bridges and heavy machinery, but has extended to many departments. America has taken away a large part of Britain's colonial trade in boots and shoes; she has a practical monopoly of the boot and shoe trade of West Australia and Africa. The boots have a better appearance and a better fit than English boots, and they wear as well. A good deal of the leather is identical in kind in the two countries, but the Americans tan better than the British. A very considerable quantity of the leather used in Britain is imported from the United States and costs less than it does at home, but though wages are smaller in Britain, American boots can be sold in the British market.

"Americans have a practical control of the match making industry in Britain, also of the tobacco industry; half of the English newspapers are printed on American presses or upon presses built on American models in English shops that are branches of American manufactories, and the paper of most of the newspapers is American." So says Mr. Frank Vanderlip, formerly assistant secretary of the Treasury.

It appears that British shipping even is to be invaded by America. In the days of wooden vessels the United States led the world in shipping, but since iron and steel have been used in shipbuilding Britain has been without a rival. At the present time, however, quite apart from the American ownership of foreign-built vessels, the tonnage of vessels built in the United States has reached a very respectable figure, being in 1901 as much as 483,489, while in February of this year it is stated that there were on the stocks twenty-two ships, averaging ten thousand tons each.

The causes that account for the position of the United States as a competitor of the United Kingdom may be grouped under two heads—the nature of the two countries and the characteristics of the two peoples. America is a large country, with immense resources and a population nearly double that of Britain. Hence, the home market is larger, and a larger home market permits of a cheaper production for the foreign market. The accessibility and abundance of some raw materials, such as coal and iron ore, gives America a great advantage. Britain can never hope again to reach America in the output of iron. Iron ore is much more easily obtained in this country, occurring in some places in large quantity of so soft a nature that it can be scooped out with steam shovels; and since it is on the surface it is possible to load it directly on cars, ready to be transported to the furnace. In Britain the ore must be mined, usually from great depths, or must be imported from other countries.

The cost of mining coal has increased in Britain as in other European countries, whereas it has decreased in America. In 1885 the average price of European coal at the mine was $1.62, and in the United States $1.58; in 1899 the European price was $1.96, while that in the United States had fallen to $1.10. The average depth of the seams in America is much less and their width is considerably greater. It is remarkable that though the output of the mines of the United Kingdom was less in 1901 than in 1900, the number of employees was 24,661 greater. This increase was, I believe, entirely in the coal mines, in which the decrease of output was over six million tons.

Of course the character of the two peoples counts for much. The power of the initiative of the American, his shrewdness and his energy give him an advantage and contrast with the Englishman's inertness, self-complacency and policy of *laissez faire*. A case was cited in the London *Mining Journal* of a firm in Australasia that sent to a British firm for a catalogue of prices. Instead of sending the catalogue, the British firm wrote for evidence of the *bona fides* of the presumable customer. The latter thereupon sent to the United States and received three large and well illustrated catalogues, and so became a customer of the American firm. It is safe to say that the majority of colonial merchants would prefer to deal with Britain if they could obtain the goods they require at the same cost and with the same ease and quickness, but sentiment must not be too much strained.

Not only is the British merchant slow to adapt himself to the wants of his customers, but the British manufacturer is slow to change old processes and to adopt new machinery. Workmen are seldom encouraged to suggest improvements in methods and machinery as they are in the United States. It is fair to say that British workmen are not very ready to make suggestions for the improvement of machinery since they have a prejudice against machinery, though any that come to America, where they find it an advantage to exercise their ingenuity, show that they can compete in inventiveness with their fellow-workmen in the United States. In Britain, however, workmen, as a rule, look upon machinery as a disadvantage. They consider that an improved machine means less hand work, and that the machine takes the bread out of the mouth of the honest laborer.

In 1901 there were in Britain no more than 311 coal cutting machines in use, while in Pennsylvania alone there were 3,125, or ten times as many. In the United States there was an output of 493 tons per man employed, in Britain only 318 tons.

The English workmen will not use machines at their full capacity, even when the machines are provided. Most of the British match factories, being under American control, use American machinery; but

in a particular case where the same company had two factories, one in Britain and one in the United States, seven hundred employees in the former turned out fewer matches than four hundred employees in the latter. The trades unions object to a man looking after more than one machine, where it might be possible for him to look after two or three, or possibly half a dozen. The trades unionists go on the assumption that there is only so much work to be done and if one man does the work of two he throws some one out of a job, forgetting that a small output at a large cost to the capitalist precludes him from competing with outside employers in the same department, and lessens the amount of work he can give to his men.

Tenders were asked for a bridge in an English colony. Several English firms and one American tendered. The lowest English tender was by a firm employing six hundred men for whom there was barely sufficient work. The English tender allowed for only five per cent. margin for profit and contingencies, but the tender was not sufficiently low, and the contract went to an American company. Within a month the English firm was obliged to dismiss one hundred men. If the employees had realized the state of the case and had been willing to work to their full capacity the contract might have been secured by the English firm, the hundred men might have still been employed and possibly others added.

Though American boots and shoes are invading Britain, two hundred riveters and finishers lately went out on strike against shoe-lasting machines. In America a hundred machines are used in the making of one boot. In England labor-saving machines have been invented, but very few have been suggested by operatives, and they are grudgingly used.

America has the advantage that the factories turn out large numbers of articles all upon the same pattern. For instance, the locomotive makers build a particular style of locomotive, and will not make any other style, except at a very great advance in cost. In England specifications are drawn up by some engineer, and these specifications must be followed. It is complained that there is a colony of consulting engineers in Westminster that have supervision of the contracts for bridges, permanent way and railway stock. It is contended that these engineers put restrictions upon English firms tendering for contracts to which American firms are not subjected. It is said, for instance, that when the Midland Railway ordered American locomotives these would not comply with the restrictions to which home made engines would be subject. When an American firm is asked to tender according to specification, the usual reply is that such a locomotive can be made, but it will cost a half more than one of the regular style that will be quite as

good. The British tender to specification is usually lower than the American. Locomotive works in England are usually smaller than in America, since most of the large railways have their own shops, and the outside constituency is small. In America few of the railroad companies make their own locomotives; they buy them from the large factories.

The case with bridges is much the same as with locomotives. The bridge companies build a number of bridges upon the same plan, hence can supply the parts for any particular contract at a rapid rate and may indeed have them on hand.

The cost of transportation in the United States is very much less than in the United Kingdom. The American cars are much larger, carrying fifty tons, whereas the English cars carry eight tons, and the American locomotives are enormous as compared with the English engines. The average charge for freight per ton mile in America is less than 0.75 cents, in Great Britain it is 2.4 cents, or more than three times as much. Of course, the short journeys in Britain increase the cost, because the terminal charges are the same whether the run has been long or short. The complaint is made in Britain that the freight on foreign goods is cheaper than on home productions, and that there is thus a discrimination against the English producer.

The United States has an advantage over the United Kingdom in the technical training afforded. In this respect Germany leads the world, but America far surpasses Britain. The total number of day students over fifteen years of age taking a technical course of twenty hours or more a week is in the whole United Kingdom only 3,873. In the Massachusetts Institute of Technology alone the number of students over eighteen years of age is about 1,200. It will be noticed that the age in the American institution is higher than that in Britain, which doubtless implies that a more advanced course of study is pursued.

The question naturally presents itself, How is Britain meeting the American competition? In some things it probably can not be met, the advantage of natural resources can not be overcome. But the English are awaking to the necessity of technical education and the importance of making the best use of their conditions. More than eleven years ago parliament placed at the disposal of the local authorities certain excise grants, commonly called 'liquor money.' Well-equipped technical schools have been started all over Britain. Two are being built in Ireland—one at Dublin, the other at Belfast—each to cost $500,000. The new Manchester Institute of Technology has just been opened. A school is being built in Glasgow to cost $750,000 for building alone. In Birmingham over two million dollars has been subscribed for a new technical training school. These expenditures are

small as compared with those of the United States, but they indicate a sense of the need of technical education.

The starting of the National Physical Laboratory for the purpose of testing and standardizing and for research on physical constants promises to be of great value. The simple standardizing of screws and nuts will be a great assistance to manufacturers. It is important that these should be made to an exact size, so that in replacing them there may be no misfits. For this it is necessary that the manufacturers' standards should be kept exact.

Trade and technical papers in Britain are awake and are sounding the alarm, which, though it falls on many deaf ears, especially in the case of those who had grown old while Britain was supreme in nearly all departments of manufacture and trade, is yet arousing some response from the younger and more active men who are beginning to learn that the world does move.

American methods are being introduced, and in some cases American energy is being imitated. The Westinghouse Company is building a five million dollar electric plant in Manchester. English bricklayers are accustomed to lay not more than four hundred bricks a day, and they started at this rate, but, under American contractors, were induced to work up to eight hundred a day. A few American bricklayers were imported and set the example of laying nearly two thousand bricks a day, whereupon the English bricklayers in their desire to show that they could equal the Yankees, followed the example set; and buildings that the English master builders said would require five years have been erected in twelve months. It is said that when the plant is installed seven thousand hands will be employed, and that it is the design of the Westinghouse Company to give a lesson to the English engineers as they have to English builders.

Though the United States is so rich in inventions, the United Kingdom is responsible for many of the pioneer inventions, and it seems that she can still make a good showing. The Bessemer process and the Thomas Gilchrist basic steel process are English inventions, and lately the Parson's Steam Turbine has gained prominence and bids fair to start a new era for steam engines. It is thought that in a few years it will be in use on all stationary engines and on steamboats.

In shipbuilding Britain still leads, the cost of building being considerably less there than in the United States. The cost of a ship of about ten thousand tons is approximately $160,000 in the United States and $130,000 in Britain.

Sir Christopher Furness, who has lately been in America, thinks that in the iron and steel trade Britain need not despair. Mr. Schwab says that the United States will be able to compete with the world in

rails, girders and heavy products, but that England will be ahead in steel products requiring special and delicate manipulation.

Probably the greatest hindrance to advance in Britain is trades unionism; but the fallacy of their doctrine may soon be realized by the workmen, and any just cause for complaint against the capitalist may be adjusted in an amicable and reasonable manner. An association called the National Industrial Association has been formed or is in the process of forming with this as one of its aims. The object is 'to create and cement a feeling of common interest between employer and employee.' The Association appeals to every engineering firm in the United Kingdom because by bringing employers and employees to see their mutual interest there will be an increase in the output of their works without additional cost. With better and cheaper work the manufacturer will be more able to combat foreign competition. Strikes and lockouts will be far less frequent, and so great loss and misery will be prevented. In this Association employers and employees meet upon the same plane, and they hope to provide machinery for conciliation which shall be available in case of any threatened dispute between employers and their men. The Association has in view the carrying on of inquiries regarding matters affecting British trade and commerce, with the object of holding their own in the markets of the world.

It will be to the interest not only of Britain, but of America as well, if British manufactures increase and if Britain grows commercially. America sells most to the richest nation—Britain is her best customer. There is no doubt that the United States will continue to develop her resources and will be able to sell to nations that can afford to buy. The standard of living is higher now than it was even a few years ago. What were luxuries to our fathers are necessities to us. There is room for all the growth possible in both Britain and America, and it is to be hoped that civilization may be advanced and the world benefited by the competition of the United States with the United Kingdom.

SCIENTIFIC READING IN A PUBLIC LIBRARY.

By ARTHUR E. BOSTWICK,

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PUBLIC libraries usually divide their circulation into ten or a dozen broad classes and so report it. This division is interesting, but a subdivision of each class would be still more so. For instance the scientific man is interested to know that a given library circulates four per cent. of science, but he would be still more interested to know exactly what is included in 'science' and how much of the circulation is to be credited to each subclass. Those libraries that use the decimal classification of Melvil Dewey, which has been so generally adopted in this country, often report together as 'science' the classes 300 (sociology), 400 (philology) and 500 (natural science) and they exclude the applications of the last-named sciences, which are placed under useful arts. It is evident that in order to mean anything, a report of circulation should be more closely subdivided. This is true of many other classes, of course, as well as of science.

PERCENTAGE OF SCIENTIFIC BOOKS CIRCULATED BY VARIOUS PUBLIC LIBRARIES.

Brooklyn	4.0	New York*	9.0
Buffalo	5.3	Philadelphia	5.9
Chicago (including Arts)	5.3	Pittsburgh	5.9
Cleveland	8.4	Providence	7.6
Los Angeles	11.5	Salem, Mass	3.3
Newark	3.4	San Francisco	7.1

And yet a public library cannot systematically classify its circulation more closely than it does. To do so would involve a great amount of labor which would be more profitably expended in other directions. It is quite possible, however, to do this extra work for a short period and in a single class of literature and the result, even if partial and perhaps not typical, can not fail to interest those whose studies and work lie in the particular line of literature that is under investigation. Such a classification of the scientific circulation was made for this purpose in all of the circulating branches of the New York Public Library (11 in number at that time) during the month of May, 1901, with the result shown in the accompanying table. For purposes of comparison the circulation is accompanied by figures showing the number of volumes in each subclass, in each branch library.

* Percentage for the entire year. That given in the larger table is for one month only.

During this month the total home circulation of these branch libraries was 131,700, and that of the sciences was 8,553, or 6.5 per cent. The first thing that strikes one is that this is a very small percentage. It is not so as compared with other libraries, as the smaller table shows; and of course it is impossible to say *a priori* what amount of scientific literature a public library ought to circulate; but taken in connection with other facts in the writer's experience as a librarian, it is believed that these figures show a general lack of public interest in science—the same lack of interest that has been brought out of late by several writers who note the general want of consideration for science and scientific men in this country as compared with those of Europe. But while this smallness of our scientific reading is doubtless symptomatic of something deeper, it is probable that interest in science might be stimulated in the library itself. The librarian has numerous effective ways of increasing the reading in a particular class of literature, but none of them appears to have been generally used in this case. Lists and bibliographies, in history, for instance, are very much more numerous than in science, probably for the reason that public librarians and also the teachers with whom they come most in contact are generally more interested in the former subject than in the latter.

Scientific men themselves could doubtless do much to better matters, and I am sure that those in charge of public libraries would welcome suggestions from them regarding the character of their scientific books and plans for making those books attractive to the public and stimulating interest in them. Men like Mr. Hodges, of Cincinnati, who is both a librarian and a scientific man, are doing much toward putting science on a better footing in our public circulating libraries, as his paper read at the recent conference of the American Library Association shows. A glance at the numerical table shows that the public interest in science is not even as great as the total figure would seem to indicate. The largest circulation by far in any one of the thirty subclasses represented is in 420—English philology. But in this are included many volumes of elementary language lessons, etc., which are used in connection with school work, and these doubtless account for the size of this figure. Next comes 370—education, and although it is interesting to see that books on this subject are so popular, their popularity has little to do with a general appreciation of the importance of scientific literature.

The next largest circulation is in 590—zoology. Here at last we have a natural science. But among works on zoology are classed a large number of popular animal stories, which probably make up a considerable number of the 778 books in this subject read during the month.

Science Circulation (N. Y. Public Library), May, 1901.	Bond.		Otten-dorfer.		Bruce.		Jackson Square.		Harlem.		Muhlen-berg.		Bloom-ingdale.		River-side.		Yorkville.		34th St		Chatham.		Totals.	
	Vols. in Lib.	Circulation.	Vols. in Lib.	Circulation.	Vols. in Lib.	Circulation.	Vols. in Lib.	Circulation.	Vols. in Lib.	Circulation.	Vols. in Lib.	Circulation.	Vols. in Lib.	Circulation.	Vols. in Lib.	Circulation.	Vols. in Lib.	Circulation.	Vols. in Lib.	Circulation.	Vols. in Lib.	Circulation.	Vols. in 11 Branches.	Circulation.
300 **Sociology**	66	17	45	15	55	15	41	6	32	14	22	12	33	16	23		28	16	13	6	23	9	381	126
310 Statistics	26	3			23	1	1	1	2	1	9		1	3	5		2	3	2		6		77	12
320 Political Science	121	17	56	21	68	18	53	20	41	16	31	13	35	13	26	2	33	18	18	15	39	8	521	161
330 " Economy	175	52	95	19	111	27	92	26	62	23	35	12	42	21	45	19	69	37	26	6	47	15	799	257
340 Law	75	41	52	27	34	8	39	11	35	18	16	5	17	9	10	2	22	11	15	2	23	8	338	142
350 Administration	92	84	55	26	68	23	61	20	44	21	29	10	39	15	25	9	58	30	20	7	39	33	530	278
360 Ass'ns and Inst'ns	22	2	11		15	1	13	2	9	2	5	2	2	2	8	1	6	1	2		1		94	13
370 Education	136	66	146	142	167	70	122	41	128	105	55	24	92	73	40	23	109	98	36	21	137	242	1168	905
380 Commerce, etc	4		10	1	14	3	8	2	8	4	4	2	5	2	4	1	3		2		1	1	63	16
390 Customs, Folk-lore	98	69	85	70	113	61	88	57	71	57	48	39	63	38	43	27	77	85	29	27	57	71	772	601
400 Philology	5	2	7	4	5	3	1				2		1	1	1		4	1					26	11
410 Comparative	3		2		5	1	5	1	3				3		1		2	1	1		1		26	3
420 English	143	197	131	204	95	37	73	52	36	57	39	4	63	71	57	33	124	136	64	73	257	829	1082	1693
430 German	41	47	60	41	43	5	13	6	25	18	13	6	13	6	1	1	25	19	4	1	38	19	276	169
440 French	36	34	29	26	58	9	15	11	15	7	17	3	9	4	9	2	25	9	9	4	35	24	257	133
450 Italian	13	5	2	1	8	2	2	1	1		1	1	1			1	2				7	5	37	16
460 Spanish	13	10	26	6	10	3	9	2	7	5	3	2	5	5			6	6	1		2	3	82	42
470 Latin	22	7	13	7	11	4	13	3	4	6	8	1	7	4	6		12	8	3	3	18	4	117	47
480 Greek	10	1	3	1	5	1	4		3		6	1	1		1		7	11	4	3	10		54	18
490 Minor Languages	1		3		2		1		1														8	
500 Natural Science	82	46	121	46	140	45	74	26	39	26	20	11	76	47	20	1	71	66	33	17	154	300	830	631
510 Mathematics	99	121	102	97	61	41	60	45	54	50	31	23	39	31	19	1	58	77	22	13	137	174	682	673
520 Astronomy	52	15	44	14	55	15	41	19	37	14	14	6	27	14	21	13	31	17	19	6	27	80	368	213
530 Physics	136	122	156	90	155	47	115	60	108	78	58	33	65	47	52	17	81	63	42	20	61	28	1029	605
540 Chemistry	44	37	51	36	42	14	36	18	24	6	12	3	16	13	9	2	18	14	7	9	20	16	279	168
550 Geology	78	39	72	34	80	13	63	17	55	12	19	5	34	12	32	5	36	23	21	12	33	19	523	191
560 Paleontology	5	1	5	1	4	1	3		4				1	1	2								24	4
570 Biology	59	24	60	21	72	23	61	15	45	18	18	12	36	23	23	16	34	18	23	8	18	8	449	186
580 Botany	64	33	66	59	70	29	61	8	59	25	27	19	36	36	31	21	59	38	23	13	111	180	607	461
590 Zoology	155	68	150	130	205	73	160	52	101	53	54	28	100	82	56	33	121	84	38	16	113	159	1253	778
Totals	1876	1160	1658	1139	1794	593	1328	522	1053	636	596	277	862	589	570	230	1123	890	477	282	1415	2235	12752	8553

Mathematics has a relatively large circulation, but we must not suppose that in May, 1901, 673 citizens of New York devoted themselves to the theory of functions or the calculus of probabilities. Further analysis would reveal the fact that a very large proportion of the books taken out were text-books on arithmetic and algebra.

An examination of the records of the separate libraries reveals some points of interest. For instance the circulation in political science and political economy at Bond Street was twice as great as at Bloomingdale—five miles above. The proportion of Hebrews among the users of the two branches must be in nearly the same ratio—a fact that speaks for itself. On the other hand the circulation in education was larger at Bloomingdale. In English philology, the Chatham Square Branch circulated nearly as many books as all the other branches together, which is noteworthy when we remember that this is in a foreign section, where there are news-stands on which not a single English newspaper is exposed for sale. The same proportion holds good at this branch for general works on natural science (class 500). Some things about the table are inexplicable. Why, for instance, should the Ottendorfer Branch have circulated twice as much zoology as Bond Street, only a half mile distant? Doubtless this was owing to some temporary demand, which another month's record might reverse.

Comparison of the circulation in each class with the number of books in that class shows, as might have been expected, that the larger the stock the larger the circulation. There is a mutual reaction between these two numbers. On the one hand, if the demand for a particular class of books is not great, in any branch library, that library naturally does not call for books on that subject; on the other hand, if a library is meagerly supplied in any subject, so that users who wish to read in that subject can not get what they want, the circulation is apt to remain small. In such cases the circulation may be raised by replenishing the stock. The ratio does not always hold good, however, and there are some notable exceptions.

Evidently these are but a very few of the considerations suggested by a study of the table. Different parts of it will naturally interest different readers, and each will be able to find may things in it that can not be brought out here. Of course the record for a whole year would be still more valuable, but, as has been said, the amount of daily labor necessary to subdivide the report is so great that its continuance beyond a month would hardly be justified. So far as I know this is the first attempt made in any library to subdivide so closely in any subject and to present the results in a form suitable for observation and study.

AN ASCENT OF MT. ORIZABA.*

By Professor ALJA ROBINSON CROOK,
NORTHWESTERN UNIVERSITY.

ORIZABA is the highest mountain in North America whose summit has been reached by mountain climbers. It lies one hundred and fifty miles southeast of Mexico City and less than sixty miles from the Gulf of Mexico and is a most attractive peak for mountaineers.

I determined to climb it, and after a week spent in Mexico City in the vain attempt to find companions for the journey took the train for San Andres, the railroad station nearest to the village of Chalchicomula, from which the ascent is most favorably begun. A broken axle delayed the train five hours. The passengers wagging their heads said the accident was to be expected, the day was the thirteenth of the month. It was evening when San Andres was reached. The station agent knew of two men in Chalchicomula who could speak English. Fortunately one of them was at home, and we were soon upon a friendly footing. He offered to find guides and horses for me, but proved to be not a very aggressive agent. A native of Florida, crowded out of his country by competition, he was teaching the Mexicans English and receiving for his work eight cents an hour. He was so doubled with rheumatism as to be scarce able to walk. After much encouragement on my part and an hour's talking on his, he engaged two guides. A horse was to be procured. It was eight o'clock at night; the rain was descending in torrents; I had eaten nothing since morning. We called at several places where horses were reported for hire and where it took the polite proprietors many minutes to explain that they did not have horses. We were making such slow progress that I finally picked my interpreter up in my arms and carried him from place to place through the rain till we had visited half a dozen polite gentlemen and finally obtained the promise of a horse for the morrow. Even the preparation for mountain climbing in that village was uphill work. That night, lying in bed, nursing a toothache, listening to the driving rain outside, remembering the remarks of the villagers that rain and snow storms and avalanches would make the ascent impossible, it seemed the extreme of foolhardiness to attempt such a thing.

In the morning the guides were late, and the horse proved to be too weak to carry a man, so I contented myself with putting blanket roll and

* Photographs by the author.

provisions on the horse and walking with the guides. There was some compensation in this, as it gave opportunity of measuring my walking ability. The guides had the advantage of being accustomed to an altitude of eight thousand feet and of living a life requiring constant walking. But before the close of the first day one of them complained of the difficulty of breathing and on the day of final ascent begged to return before the climb was completed. After three years of mountaineering with European university students, I am of the opinion that the American college man of average athletic habits can walk with the men of any nation. Good ancestry, good food, good habits of life, produce good muscle. In the same class with the American come the

FIG. 1. MOUNT ORIZABA, FROM CHALCHICOMULA.

English and the Russian student, while the German and French are in a second class, and the Latin races in a third largely because of their habits of life.

By eight o'clock we had started for the mountain. The little burro, buried under food, bedding, ax and shovel, led the procession. A guide followed to encourage the burro and lead the *caballo*. The second guide came next to encourage the horse. I followed. The preceding evening I had searched the lexicon to learn to say 'whoa.' Unnecessary labor! The only expression needed was 'Get up!'—and that in the universal language of the birch stick.

A short climb soon brought us above the town and showed the flat-roofed plaster houses thickly crowded together without door-yards or pavements in the narrow streets. Several churches rising above the

general mass of buildings gave picturesqueness to the scene. Before us not more than a dozen miles away, and seemingly less, was Orizaba. Usually the traveler in mountain regions is disappointed in the peaks he would visit, because they are dwarfed by the neighboring hills and mountain spurs surrounding them, and seem flat and tame. But on that August morning Orizaba was the most majestic mountain that could be conceived. It was the very picture of just such a mountain as a plainsman would draw. Its sharp summit pierced the sky with such favorable perspective that the great height could be really appreciated. Snow came far down upon its sides. The treeless tract below the snow line stood out plainly and ended with thick forests which covered the

FIG. 2. CHALCHICOMULA, AND OUTFIT FOR THE ASCENT OF MOUNT ORIZABA.

hills rounded and piled up over the mountain's base. A well-marked trail led through the fields, some filled with black stalked corn, some bristling with thousands of that valuable cactus, called *maguay* in Mexico and century plant in the United States, and some entirely barren. A horseback rider with a revolver at his belt came dashing through the thicket and asked a drink of the guides. Though they were going on a three days' trip and had but a quart of wine between them they handed the man their bottle, how unwillingly I do not know. Possibly the beggar was the proprietor of the hacienda through which we were passing and took that means to levy toll. After two hours' walking we reached the forest belt and spent the remainder of the day within it. As in all mountain regions here the most common and stately trees are pines and spruce. The pines flourish from nine thousand feet

up to the tree limit—between thirteen and fourteen thousand feet. Spruce trees thrive best above the ten-thousand-foot line. There is very little undergrowth and the country is park-like. The absence of animal life is noticeable. Ants, flies, mosquitos, birds and mammals that are so abundant in most parts of the world are rare here. The only reptiles that I saw were occasional salamanders. The slopes are easy and regular, so that little energy is wasted by the necessity of descending from heights once reached.

During the day shifting clouds revealed one beauty after another by blotting out one portion of the heavens or mountains and calling attention to others. Occasionally the splendid summit of Orizaba would appear, then the top of a neighboring mountain, as if nature were try-

FIG. 3. MOUNT ORIZABA FROM ELEVATION OF ABOUT 8,500 FT., ABOUT 12 MILES AWAY.

ing the effect of draperies. Sometimes the clouds would envelop us with their cold folds and shut out from view all but the nearest trees.

At four in the afternoon, though much too early according to my judgment, we halted and prepared a camp under the shelter of a cliff, whose base is hollowed out in the form of a shallow cave. It affords poor protection. The rain coming from one direction is shut off, but water drips from the rocks. Just after darkness had begun to settle down we heard a far-away shout as if from some one in distress. We answered and soon found that it was simply a shepherd calling his flock. It was a cold night and sleeping out of doors at that altitude is not a luxury. In the morning my rubber blanket was stiff with a sheet of ice.

This 'cave' was probably the place where Baron Müller, who climbed the mountain in 1856, stopped, and where nearly all the mountaineers who have attempted the ascent since have passed the night. Müller speaks of the 'granite' walls of the cave and other tourists use the same term. But there is no granite here nor elsewhere in the region. The rock masses forming the mountain are singularly uniform. They are eruptive rocks of prevailing dark grayish or brownish color composed of crystals of augite and plagioclase in a fine ground mass and are called andesite. In places glassy masses of obsidian appear, and in others volcanic tuffs and ashes, but in no place is there granite or gneiss.

FIG. 4. FOREST ON MOUNT ORIZABA IN THE DISTANCE—100 MILES AWAY—POPOCATEPETL AND IZTACCIHAUTL.

The following morning at six o'clock, after a hurried breakfast, one guide and I started for the summit. In a few minutes we were above the timber line. Two hours of walking brought us to the snow line, that day at about fifteen thousand feet.

At the lower levels the snow is finely crystalline, very compact and of the variety known as 'firn' or 'névé.' It affords excellent footing to the properly shod climber. Toward the top of the mountain it is softer, though the individual flakes are never large, and the feet sink in to the shoe tops. The beauty of the snow furnishes one of the great rewards to the tourist. The spike of an alpine stock leaves after each thrust a hole of wondrous green in the glittering white mass. The snow fills the chasms of the mountain, smoothes out its ridges, softens

its outline, gives it a dazzling splendor—a crown of glory worn only by the kings among mountains.

For five hours we plodded upward through the snow. With woolen socks pulled partly over the shoes so as to leave the rubber heels exposed, I found it easy to walk up the steep smooth slopes which held the feet almost like sandpaper. But my guide's wide sandals could not hold to the snow, consequently he had to cut steps. When he became exhausted I took his place, and thus we alternated. Exertion at that altitude is difficult. At the cave to roll over on a blanket and pull it over the shoulder almost makes one pant. 'And to pull the blanket over both shoulders would make a pair of pants, I suppose,' said my hostess at a dinner party a few months later, when the story was being related.

FIG. 5. MOUNT ORIZABA FROM 12,000 FT. ELEVATION. SNOW EXTENDING DOWN TO THE 15,000 FT. LINE.

During the ascent of mountains up to fourteen thousand feet in height heretofore mountain sickness has not caused me much annoyance. But for the last three thousand feet of the ascent of Orizaba, headache, pain at the top of the spinal cord, rapid beating of the heart, shortness of breath, inability to eat even a cracker or chocolate, general discomfort nearly destroyed all pleasure. I have never noticed the popularly reported tendency to bleeding at the nose and ears. Olives and lemon juice were the only things I could swallow. This *mal de montagne* was less severe when clouds obscured the sun than when the glare was brightest, and less noticeable when we were in hollows than when we

were on *aretes*. When exhausted from climbing and shoveling the only thing to do was to lie down and often to sleep for a few minutes. While resting we needed only to start boulders rolling down the snow fields to behold a thrilling sight. The black masses would begin with small leaps, leaving behind indentations like an unwinding white ribbon in the dazzling snow. Increasing in speed, the boulders would finally dash with cannon-ball velocity and mighty springs out of view thousands of feet below. An obstacle at the beginning so slight as to be unnoticed would often change the path of the boulders started from the same spot so that their lower lines would be a mile apart—one making a path down a gully to the south perchance and another down an eastern gully. Form, color and motion combined to give an astonishing effect. Of the many mountain slopes that I have seen this is the most favorable for such a sight.

The weather had been propitious all morning. Though threatening, the clouds shifted constantly and disclosed one extensive view after another—any one of them a complete compensation for the effort of the ascent. Finally, after we had been climbing seven hours and were within probably three hundred feet of the rim of the crater, a vigorous snow storm swept around the mountain. We continued the ascent for an hour. The cold and wind increased. It was impossible to see fifty yards. There was nothing to do but begin the descent. We had not seen the crater nor had we had a view from the summit. But our rewards had been enjoyed all the way up and the wisdom of not postponing the return afterwards appeared since the snow storm continued the remainder of the day. So after waiting half an hour and finding the storm becoming worse, we tobogganed down the snow slope, and in fifteen minutes passed over the distance which had required three hours to climb.

We reached the cave camp in two hours, and I spent the night in bathing eyes to take out inflammation caused by the excessive light experienced on the snow.

The next morning we returned to Chalchicomula, and the tram which runs eight miles without animal, steam, or electrical traction simply with the force of gravity, carried me to San Andres, and in a few hours I was taking photographs of banana groves and coffee plantations in the city of Orizaba, having passed from frigid to tropical regions in one day.

Orizaba, 'the Star Mountain,' is the most favorable mountain in the world for an American who wishes to climb higher than eighteen thousand feet. Elbruz, the culminating point of Europe, is less accessible to Europeans than Orizaba to Americans.

The starting point for the ascent of Orizaba is high, the slopes ridable up to fourteen thousand feet, and easy the entire distance to the

summit. Ice work is unnecessary. The guides are of obliging disposition and moderate in charges. They wear sandals and for ice work wrap their feet in strips of cloth. They provide the same primitive and clumsy footgear for the tourist. Knickerbockers, woolen stockings, canvas leggings or puttees, and shoes protected with rubber are the most satisfactory clothing. The guides greatly admired my golf stockings which were hanging before the fire at the cave. They would feel them repeatedly exclaiming *'Magnifico, magnifico.'*

The earliest recorded ascent of Orizaba is that made by some United States army officers in 1848. But no one in the country credited their report. Three years later eighteen young men of different nationalities formed a party and started for the summit. One man after another dropped out of the company till finally only a Frenchman by the name of Doignon was left. He persevered and after great hardships reached the summit. Upon his return to Chalchicomula the villagers ridiculed the claim. Consequently the following week he repeated the ascent and planted a flag upon the ridge of the crater, where it could be plainly seen by the doubting inhabitants. He was received with honor when he descended. Since Baron Müller's ascent in 1856 more than a dozen climbers have reached the summit and made many measurements of altitude.* Miss Anna Peck, of New York City, who is an experienced mountain climber, displayed great courage and endurance in her ascent of Orizaba. She is the only woman who has ever succeeded in reaching its summit so far as I am aware.

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* Reports upon the altitude of Orizaba:

North American Engineers in 1848	17,879	
Ferran	17,885	
Müller	18,133	
Doignon	18,178	(Determined by boiling point of water.)
Scovill and Bunsen	18,174	" by aneroid barometer.
Heilprin	18,205	" " " "
Kaska	18,270	" " mercurial "
Scovill and Bunsen	18,314	" " triangulation.

ORIGIN OF THE FINS OF FISHES.

By President DAVID STARR JORDAN,
LELAND STANFORD JR. UNIVERSITY.

ONE of the most interesting problems in vertebrate morphology, and one of the most important from its wide-reaching relations, is that of the derivation of the fins of fishes. This resolves itself at once into two problems, the origin of the median fins, which appear in the lancelets, at the very bottom of the fish-like series, and the origin of the paired fins or limbs, which are much more complex, and which first appear with the primitive sharks.

In this study the problem is to ascertain not what theoretically should happen, but what, as a matter of fact, has happened in the early history of the fish-like groups. That these structures, with the others in the fish body, have sprung from simple origins, growing more complex with the demands of varied conditions, and then at times again simple, through degeneration, there can be no doubt. It is also certain that each structure must have had some element of usefulness in all its stages. In such studies we have, as Haeckel has expressed it, 'three ancestral documents, paleontology, morphology and ontogeny,'—the actual history as shown by fossil remains, the side-light derived from comparison of structures, and the evidence of the hereditary influences shown in the development of the individual. As to the first of these ancestral documents, the evidence of paleontology is conclusive where it is complete. But in very few cases are we sure of any series of details. The records of geology are like a book with half its leaves torn out, the other half confused, displaced and blotted.

The evidence of comparative anatomy is most completely secured, but it is often indecisive as to relative age and primitiveness of origin among structures. As to ontogeny, it is, of course, true that through heredity, 'the life history of the individual is an epitome of the life history of the race.' 'Ontogeny repeats phylogeny,' and phylogeny, or line of descent of organisms and structures, is what we are seeking. But here the repetition is never perfect, never so perfect in fact as Haeckel and his followers expected to find it. The demands of natural selection may lead to the lengthening, shortening, or distortion of phases of growth, just as they may modify adult conditions. The conditions of the individual development may, therefore, furnish evidence in favor of certain theories of origins, but they cannot alone furnish the absolute proof.

Origin of the Median or Vertical Fins.

In the process of development the median or vertical fins are doubtless older than the paired fins or limbs, whatever be the origin of the latter. They arise in a dermal keel which is developed in a web fitting and accentuating the undulatory motion of the body. In the embryo of the fish the continuous vertical fin from the head along the back and around the tail precedes any trace of the paired fins.

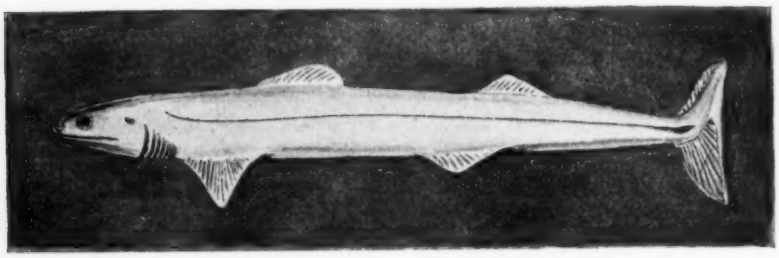
In this elementary fin-fold slender supports, the rudiments of fin-rays, tend to appear at intervals. These are called by Ryder ray-hairs or actinotrichia. They are the prototype of fin-rays in the embryo fish, and doubtless similarly preceded the latter in geological time. In the development of fishes, the caudal fin becomes more and more the seat of propulsion. The fin-rays are strengthened, and their basal supports are more and more specialized.

That the vertical fins, dorsal, anal and caudal, have their origin in a median fold of the skin admits of no very serious question. In the lowest forms which bear fins these structures are dermal folds, being supported by very feeble rays. Doubtless, at first the vertical fins formed a continuous fold, extending around the tail, this fold ultimately broken by atrophy into distinct dorsal, anal and caudal fins. In the lower fishes, as in the earlier sharks, there is an approach to this condition of primitive continuity, and in the embryos of almost all fishes the same condition occurs. Dr. John A. Ryder points out the fact that there are certain unexplained exceptions to this rule. The sea-horse, pipe-fish and other highly modified forms do not show this unbroken fold, and it is wanting in the embryo of the top-minnow, *Gambusia affinis*. Nevertheless, the existence of a continuous vertical fold in the embryo is the rule, almost universal. The codfish with three dorsals, the Spanish mackerel with dorsal and anal finlets, the herring with one dorsal, the stickleback with a highly modified one, all show this character and we may well regard it as a certain trait of the primitive fish. This fold springs from the ectoblast or external series of cells in the embryo. The fin-rays and bony supports of the fins spring from the mesoblast or middle series of cells, being thrust upward from the skeleton as supports for the fin-fold.

Origin of the Paired Fins.

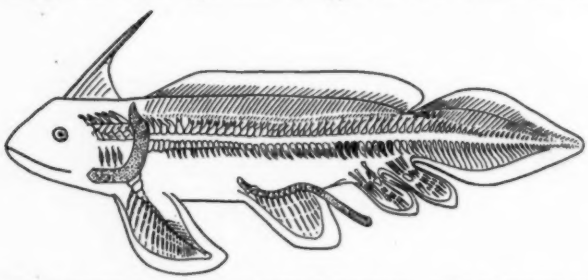
The question of the origin of the paired fins is much more difficult and is still far from settled, although the majority of recent writers have favored the theory that these are parts of a once continuous lateral fold of skin, corresponding to the vertical fold which forms the dorsal, anal and caudal. In this view the lateral fold is soon atrophied in the middle, while at either end it is highly specialized, at first into an organ

of direction, then into fan-shaped and later paddle-shaped organs of locomotion. Finally, from the jointed paddle, which Gegenbaur has called the archipterygium, there has developed, on the one hand, the rayed pectoral and ventral fins of ordinary fishes, and on the other, in land-creeping animals, jointed legs and arms. As to this the evidence of paleontology is conflicting. An early shark of the Devonian, *Cladose-*



CLADOSELACHE FYLERI. AFTER DEAN.

lache, has fan-shaped paired fins so formed and placed. Another shark almost as old, *Pleuracanthus,* of the Carboniferous, has fins which fit best a totally different theory of origin. Its jointed or archipterygial fin has no resemblance to a fold of skin, but accords better with Gegenbaur's theory that the pectoral limb was at first a modified septum or gill arch. Sharks still older than either (Heterodontidæ) in the Silurian, so far as we can judge by their teeth, are closely related to forms bearing the more specialized type of fin found in the typical



PLEUROCANTHUS DECHENI RESTORED. AFTER BROGNIART. THE ANTERIOR ANAL VERY HYPOTHETICAL.

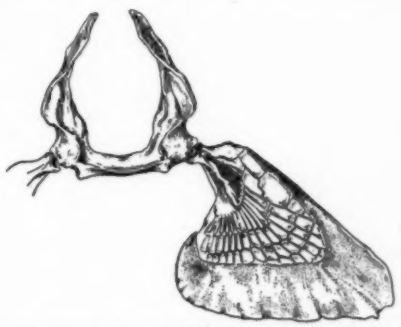
sharks of to-day. Evidently none of these three, as seen in the rocks, represents the real beginning of paired fins in the life of the past. As we shall see, the evidence of comparative anatomy may be consistent with either of these theories, while that of ontogeny or embryology is apparently inconclusive, and that of paleontology seems contradictory.

Development of the Paired Fins in the Embryo.

According to Dr. John A. Ryder ('Embryography of Osseous Fishes,' 1882) "the paired fins in Teleostei, like the limbs of the higher

vertebrates, arise locally, not, however, as blunt processes but as short longitudinal folds, with perhaps a few exceptions. The pectorals of *Lepisosteus* originate in the same way. Of the paired fins, the pectoral or anterior pair seems to be the first to be developed, the ventral or pelvic pair often making its appearance until after the absorption of the yolk-sac has been completed, in other cases, before that event as in *Salmo* and in *Gambusia*. The ventral undergoes less alteration of position during its evolution than the posterior pair."

In the codfish (*Gadus callarias*) the pectoral fin-fold "appears as a slight longitudinal elevation of the skin on either side of the body of the embryo a little way behind the auditory vesicles, and shortly after the tail of the embryo begins to bud out. At the very first, it appears to be merely a dermal fold, and in some forms, a layer of cells extends out underneath it from the sides of the body but does not ascend into it. It begins to develop as a very low fold, hardly noticeable, and as growth proceeds, its base does not expand antero-posteriorly but tends rather to become narrowed, so that it has a pedunculated form. With the progress of this process the margin of the fin-fold also becomes thinner at its distal border, and at the basal part mesodermal cells make their appearance more noticeably within the inner contour line. In some species I am quite assured that there is a mesodermal tract or plate of cells developed just behind the auditory vesicles, just outside the source of the mesodermal cells which are carried up into the pectoral fin-fold. This is developed at about the time of the closure of the blastoderm and these lateral mesodermal folds of tissue may be called the pectoral plates. The free border of the fin-fold grows out laterally and longitudinally, expanding the portion outside of the inner contour line of the fin into fan-shape. This distal thinner portion is at first without any evidence of rays; further than that there is a manifest tendency to a radial disposition of the histological elements of the fin."



PECTORAL FIN OF HEPTERODONTUS PHILIPPI. FROM NATURE.

The next point of interest is found in the change of position of the pectoral fin by a rotation on its base. This is associated with changes in the development of the fish itself. The ventral fin is also, in most fishes, a short horizontal fold and just above the preanal part of the median vertical fold which becomes anal, caudal and dorsal. But in the top-minnow (*Gambusia*), of the order Haplomi, the ventral first

appears as 'a little papilla and not as a fold, where the body walls join the hinder upper portion of the yolk-sac, a very little way in front of the vent.' 'These two modes of origin,' observes Dr. Ryder, 'are therefore in striking contrast and well calculated to impress us with the protean character of the means at the disposal of Nature to achieve one and the same end.'

Current Theories.

There are three chief theories as to the morphology and origin of the paired fins:

The earliest is that of Gegenbaur, supported by numerous others, that these fins are derived from modified gill-arches or septa between the gill-openings. According to this theory, the skeletal arrangements of the vertebrate limb are derived from modifications of one primitive form, a structure made up of successive joints, with a series of fin-rays on each side of it. To this structure, Gegenbaur gives the name of archipterygium. It is found in the shark, *Pleuracanthus,* and in all the Dipnoan and Crossopterygian fishes, its primitive form being still retained in the Australian genus of Dipnoans, *Neoceratodus.* This biserial archipterygium with its limb girdle is derived from a series of gill rays attached to a branchial arch.

Professor J. Graham Kerr observes:

"The Gegenbaur theory of the morphology of vertebrate limbs thus consists of two very distinct portions. The first, that the archipterygium is the ground-form from which all other forms of presently existing fin skeletons are derived, concerns us only indirectly as we are dealing here only with the *origin* of the limbs, *i. e.,* their origin from other structures that were not limbs.

"It is the second part of the view that we have to do with, that deriving the archipterygium, the skeleton of the primitive paired fin, from a series of gill-rays and involving the idea that the limb itself is derived from the septum between two gill clefts.

"This view is based on the skeletal structures within the fin. It rests upon: (1) The assumption that the archipterygium is the primitive type of fin, and (2) the fact that amongst the Selachians is found a tendency for one branchial ray to become larger than the others, and when this has happened, for the base of attachment of neighboring rays to show a tendency to migrate from the branchial arch on to the base of the larger or, as we may call it, primary ray; a condition coming about which, were the process to continue rather further than it is known to do in actual fact, would obviously result in a structure practically identical with the archipterygium. Gegenbaur suggests that the archipterygium actually has arisen in this way in phylogeny.

The theory of Balfour, adopted by Dohrn, Wiedersheim, Thacher,

Mivart, Ryder, Dean, Boulenger and others, and now generally accepted by most morphologists as plausible, is this: that "The paired limbs are persisting and exaggerated portions of a fin-fold once continuous, which stretched along each side of the body and to which they bear an exactly similar phylogenetic relation as do the separate dorsal and anal fins to the once continuous median fin-fold."

"This view, in its modern form, was based by Balfour on his observation that in the embryos of certain Elasmobranchs the rudiments of the pectoral and pelvic fins are at a very early period connected together by a longitudinal ridge of thickened epiblast—of which indeed they are but exaggerations. In Balfour's own words referring to these observations: 'If the account just given of the development of the limb is an accurate record of what really takes place, it is not possible to deny that some light is thrown by it upon the first origin of the vertebrate limbs. The facts can only bear one interpretation, viz., that the limbs are the remnants of continuous lateral fins.'

"A similar view to that of Balfour was enunciated almost synchronously by Thacher and a little later by Mivart—in each case based on anatomical investigation of Selachians—mainly relating to the remarkable similarity of the skeletal arrangements in the paired and unpaired fins."

A third theory is suggested by Mr. J. Graham Kerr (*Cambridge Philos. Trans.*, 1899), who has given us the best recent summary of the theories on this subject. Mr. Kerr agrees with Gegenbaur as to the primitive nature of the archipterygium, but believes that it is derived, not from the gill-septum but from an external gill. Such a gill is well developed in the young of all the living sharks, Dipnoans and Crossopterygians, and in the latter types of fishes it has a form strikingly similar to that of the archipterygium, although without bony or cartilaginous axis.

We may now take up the evidence in regard to each of the different theories, using largely the language of Kerr, the paragraphs in quotation marks being taken from his paper. We may first consider Balfour's theory of the lateral fold.

Balfour's Theory of the Lateral Fold.

"The evidence in regard to this view may be classed under three heads, as Ontogenetic, Comparative Anatomical, and Paleontological. The ultimate fact on which it was founded was Balfour's discovery that in certain Elasmobranch embryos, but especially in *Torpedo* (*parcoatis*), the fin rudiments were, at an early stage, connected by a ridge of epiblast. I am not able to make out what were the other forms in which Balfour found this ridge, but subsequent research, in particular by

Mollier, a supporter of the lateral-fold view, is to the effect that it does not occur in such ordinary sharks as *Pristiurus* and *Mustelus,* while it is to be gathered from Balfour himself that it does not occur in *Scyllium* (*Scylliorhinus*).

"It appears to me that the knowledge we have now that the longitudinal ridge is confined to the rays and absent in the less highly specialized sharks, greatly diminishes its security as a basis on which to rest a theory. In the rays, in correlation with their peculiar mode of life, the paired fins have undergone (in secondary development) enormous extension along the sides of the body, and their continuty in the embryo may well be a mere foreshadowing of this.

"An apparently powerful support from the side of embryology came in Dohrn and Rabl's discoveries that in *Pristiurus* all the interpterygial myotomes produce muscle buds. This, however, was explained away by the Gegenbaur school as being merely evidence of the backward migration of the hind limb—successive myotomes being taken up and left behind again as the limb moved further back. As either explanation seems an adequate one, I do not think we can lay stress upon this body of facts as supporting either one view or the other. The facts of the development of the skeleton can not be said to support the fold view; according to it we should expect to find a series of metameric supporting rays produced which later on become fused at their bases. Instead of this we find a *longitudinal* bar of cartilage developing quite continuously, the rays forming as projections from its outer side.

"The most important evidence for the fold view from the side of comparative anatomy is afforded by: (1) The fact that the limb derives its nerve supply from a large number of spinal nerves, and (2) the extraordinary resemblance met with between the skeletal arrangements of paired and unpaired fins. The believers in the branchial-arch hypothesis have disposed of the first of these in the same way as they did the occurrence of interpterygial myotomes, by looking on the nerves received from regions of the spinal cord anterior to the attachment of the limb as forming a kind of trail marking the backward migration of the limb.

"The similarity in the skeleton is indeed most striking, though its weight as evidence has been recently greatly diminished by the knowledge that the apparently metameric segmentation of the skeletal and muscular tissues of the paired fins is quite secondary and does not at all agree with the metamery of the trunk. What resemblance there is may well be of a homoplastic character when we take into account the similarity in function of the median and unpaired fins, especially in such forms as *Raja* where the anatomical resemblances are especially striking. There is a surprising dearth of paleontological evidence in favor of this view."

Objections to the Theory of the Lateral Fold.

The objection to the first view is its precarious foundation. Such lateral folds are found only in certain rays, in which they may be developed as a secondary modification in connection with the peculiar form of these fishes. Professor Kerr observes that this theory must be looked upon and judged:

"Just as any other view at the present time regarding the nature of the vertebrate limb, rather as a speculation, brilliant and suggestive though it be, than as a logically constructed theory of the now known facts. It is, I think, on this account allowable to apply to it a test of a character which is admittedly very apt to mislead, that of 'common sense.'

"If there is any soundness in zoological speculation at all I think it must be admitted that the more primitive vertebrates were creatures possessing a notochordal axial skeleton near the dorsal side, with the main nervous axis above it, the main viscera below it, and the great mass of muscle lying in myotomes along its sides. Now such a creature is well adapted to movements of the character of lateral flexure, and not at all for movements in the sagittal plane—which would be not only difficult to achieve but would tend to alternately compress and extend its spinal cord and its viscera. Such a creature would swim through the water as does a Cyclostome, or a Lepidosiren, or any other elongated vertebrate without special swimming organs. Swimming like this, specialization for more and more rapid movement, would mean flattening of the tail region and its extension into an at first not separately mobile median tail fold. It is extremely difficult to my mind to suppose that a new purely *swimming* arrangement should have arisen involving up and down movement, and which, at its first beginnings, while useless as a swimming organ itself, must greatly detract from the efficiency of that which already existed."

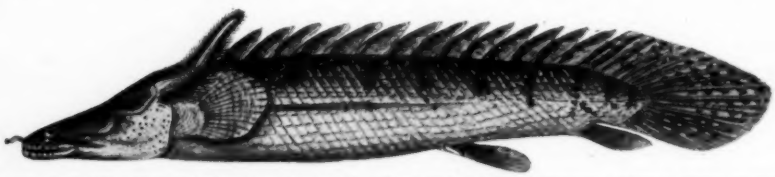
Objections to Gegenbaur's Theory.

We now return to the Gegenbaur view—that the limb is a modified gill septum.

"Resting on Gegenbaur's discovery already mentioned that the gill-rays in certain cases assume an arrangement showing great similarity to that of the skeletal elements of the archipterygium, it has, so far as I am aware, up to the present time received *no* direct support whatever of a nature comparable with that found for the rival view in the fact that, in certain forms at all events, the limbs actually do arise in the individual in the way that the theory holds they did in phylogeny. No one has produced either a form in which a gill septum becomes the limb during ontogeny, or the fossil remains of any form which shows an intermediate condition.

"The portion of Gegenbaur's view which asserts that the biserial archipterygial fin is of an extremely primitive character is supported by a large body of anatomical facts, and is rendered further probable by the great frequency with which fins apparently of this character occur amongst the oldest known fishes. On the lateral fold view we should have to regard these as independently evolved, which would imply that fins of this type are of a very perfect character, and in that case we may be indeed surprised at their so complete disappearance in the more highly developed forms, which followed later on."

As to Gegenbaur's theory it is urged that no form is known in which a gill septum develops into a limb during the growth of the individual. The main thesis, according to Professor Kerr, "that the archipterygium was derived from gill-rays, is supported only by evidence of an indirect character. Gegenbaur in his very first suggestion of his theory pointed out, as a great difficulty in the way of its acceptance, the position of the



POLYPTERUS CONGICUS, A CROSSOPTERYGIAN FISH FROM CONGO RIVER; YOUNG WITH EXTERNAL GILLS. AFTER BOULENGER

limbs, especially of the pelvic limbs, in a position far removed from that of the branchial arches. This difficulty has been entirely removed by the brilliant work of Gegenbaur's followers, who have shown from the facts of comparative anatomy and embryology that the limbs, and the hind limbs especially, actually have undergone, and in ontogeny do undergo, an extensive backward migration. In some cases Braus has been able to find traces of this migration as far forward as a point just behind the branchial arches. Now, when we consider the numbers, the enthusiasm, and the ability of Gegenbaur's disciples, we cannot help being struck by the fact that the *only* evidence in favor of this derivation of the limbs has been that which tends to show that a migration of the limbs backwards has taken place from a region somewhere near the last branchial arch, and that they have failed utterly to discover any intermediate steps between gill-rays and archipterygial fin. And if for a moment we apply the test of common sense we cannot but be impressed by the improbability of the evolution of a gill septum, which in all the lower forms of fishes is fixed firmly in the body wall, and beneath its surface, into an organ of locomotion.

"May I express the hope that what I have said is sufficient to show in what a state of uncertainty our views are regarding the morphological

nature of the paired fins, and upon what an exceedingly slender basis rest both of the two views which at present hold the field?"

Kerr's Theory of Modified External Gills.

"It is because I feel that in the present state of our knowledge neither of the two views I have mentioned has a claim to any higher rank than that of extremely suggestive speculations that I venture to say a few words for the third view, which is avowedly a mere speculation.

"Before proceeding with it I should say that I assume the serial homology of fore- and hind-limbs to be beyond dispute. The great and deep-seated resemblances between them are such as to my mind seem not to be adequately explicable except on this assumption.

"In the Urodela (salamanders) the external gills are well-known structures—serially arranged projections from the body wall near the upper ends of certain of the branchial arches. When one considers the ontogenetic development of these organs, from knob-like outgrowth from the outer face of the branchial arch, covered with ectoderm and possessing a mesoblastic core, and which frequently if not always appear before the branchial clefts are open, one cannot but conclude that they are morphologically projections of the outer skin and that they have nothing whatever to do with the gill pouches of the gut wall. Amongst the Urodela one such gill projects from each of the first three branchial arches. In *Lepidosiren* there is one on each of branchial arches I.–IV. In *Polypterus* and *Calamoichthys* (*Erpetoichthys*) there is one on the hyoid arch. Finally, in many Urodelan larvæ we have present at the same time as the external gills a pair of curious structures called balancers. At an early stage of my work on *Lepidosiren,* while looking over other vertebrate embryos and larvæ for purposes of comparison, my attention was arrested by these structures, and further examinations by section and otherwise, convinced me that they were serial homologues of the external gills, situated on the mandibular arch. On then looking up the literature, I found that I was by no means first in this view. Rusconi had long ago noticed the resemblance, and in more recent times both Orr and Maurer had been led to the same conclusion as I had been. Three different observers having been independently led to exactly the same conclusions, we may, I think, fairly enough regard the view I have mentioned of the morphological nature of the balancers as probably a correct one.

"Here then, we have a series of homologous structures projecting from each of the series of visceral arches. They crop up on the Crossopterygii, the Dipnoi and the Urodela, *i. e.,* in three of the most archaic of the groups of Gnathatomata. But we may put it in another way. The groups in which they do *not* occur are those whose young possess a

very large yolk-sac (or which are admittedly derived from such forms). Now wherever we have a large yolk-sac we have developed on its surface a rich network of blood vessels for purposes of nutrition. But such a network *must necessarily* act as an extraordinarily efficient organ of respiration, and did we not know the facts we might venture to prophesy that in forms possessing it any other small skin organ of respiration would tend to disappear.

"No doubt these external gills are absent also in a few of the admittedly primitive forms such as, *e. g.*, (neo-) *Ceratodus*. But I would ask that in this connection one should bear in mind one of the marked characteristics of external gills—their great regenerative power. This involves their being extremely liable to injury and consequently a source of danger to their possessor. Their absence, therefore, in certain cases may well have been due to natural selection. On the other hand, the *presence* in so many lowly forms of these organs, the general close similarity in structure that runs through them in different forms and the exact correspondence in their position and relations to the body can, it seems to me, *only* be adequately explained by looking on them as being homologous structures inherited from a common ancestor and consequently of great antiquity in the vertebrate stem."

As to the third theory, Professor Kerr suggests tentatively that the external gill, as developed in salamanders and in the young *Lepidosiren*, may be the structure modified to form the paired limbs. Of the homology of fore and hind limbs and consequently of their like origin there can be no doubt.

The general gill structures have, according to Kerr, "the primary function of respiration. They are also, however, provided with an elaborate muscular apparatus comprising elevators, depressors and adductors, and larvæ possessing them may be seen every now and then to give them a sharp backward twitch. They are thus *potentially* motor organs. In such a Urodele as *Amblystoma* their homologues on the mandibular arch are used as supporting structures against a solid substratum exactly as are the limbs of the young *Lepidosiren*.

"I have, therefore, to suggest that the more ancient Gnathostomata possessed a series of potentially motor, potentially supporting structures projecting from their visceral arches; it was inherently extremely probable that these should be made use of when actual supporting and motor appendages had to be developed in connection with clambering about a solid substratum. If this had been so we should look upon the limb as a modified external gill; the limb girdle, with Gegenbaur, as a modified branchial arch.

"This theory of the vertebrate paired limb seems to me, I confess, to be a more plausible one on the face of it than either of the two which

at present hold the field. If untrue it is so dangerously plausible as to surely deserve more consideration than it appears to have had. One of the main differences between it and the other two hypotheses is that, instead of deriving the swimming fin from the walking and supporting limb, it goes the other way about. That this is the safer line to take seems to me to be shown by the consideration that a very small and rudimentary limb could *only* be of use if provided with a fixed *point d'appui*. Also on this view, the pentadactyle limb and the swimming fin would probably be evolved independently from a simple form of limb. This would evade the great difficulties which have beset those who have endeavored to establish the homologies of the elements of the pentadactyle limb with those of any type of fully-formed fin."

Uncertain Conclusions.

In conclusion, we may say that the evidence of embryology in this matter is inadequate, that of morphology is inconclusive and perhaps the final answer may be given by paleontology. If the records of the rocks were complete they would be decisive. At present we have to decide which is the more primitive of two forms of pectoral fin actually known among fossils. That of *Cladoselache* is a low, horizontal fold of skin, with feeble rays, called by Cope *ptychopterygium*. That of *Pleuracanthus* is a jointed paddle-shaped appendage with a fringe of rays on either side. In the theory of Gegenbaur and Kerr *Pleuracanthus* must be, so far as the limbs are concerned, the form nearest the primitive limb-bearing vertebrate. In Balfour's theory *Cladoselache* is nearest the primitive type from which the other and with it the archipterygium of later forms may be derived.

Boulenger and others question even this, believing that the archipterygium in *Pleuracanthus* and that in *Neo-Ceratodus* and its Dipnoan and Crossopterygian allies have been derived independently from the archipterygium in the primitive sharks. In the one theory, the type of *Pleuracanthus* would be ancestral to the other sharks, on the one hand, and to Crossopterygians and all higher vertebrates on the other. With the theory of the origin of the pectoral from a lateral fold, *Pleuracanthus* would be merely a curious specialized offshoot from the primitive sharks, without descendants and without special significance in phylogeny.

As elements bearing on this decision we may note that the tapering unspecialized diphycercal tail of *Pleuracanthus* seems very primitive in comparison with the short heterocercal tail of *Cladoselache*. This evidence, perhaps deceptive, is balanced by the presence on the head of *Pleuracanthus* of a highly specialized serrated spine, evidence of a far from primitive structure.

DOMESTIC AND INTERCOLLEGIATE ATHLETICS.*

By Professor CALVIN M. WOODWARD,
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I NEED no statistics to prove that engineering schools and engineering departments as a rule take no active part in intercollegiate athletics. There may be exceptions, but we never hear of the Massachusetts Institute of Technology, or Troy, or Worcester, or Stevens, on the gridiron or on the diamond or in regattas. How the teams are made up at Harvard and Yale, Cornell, Wisconsin, Michigan and Pennsylvania, I do not know, but I suspect that student engineers are generally 'too busy' to find time, and too interested in their work to feel an overmastering craving for athletics, so the athletic spirit which occasionally bursts into flame is gradually quenched by the steady stream of 'lectures' and 'laboratory calls.'

Doubtless we have all been somewhat to blame in this matter. We have seen so much that the student engineer ought to get and to do, and so much that the future engineer ought to know and to be, that we have pre-empted the students' hours of play and recreation as well as their hours of study, and have overlooked the plain duty of attending to the physical natures and appetites of the young men in our charge.

It is my conviction that we have made a serious mistake. To a certain degree we have defeated ourselves. Faculties and boards of control have great responsibilities in the direction of athletics, which responsibilities in a vast majority of cases they fail to meet properly. Sometimes they grossly mismanage matters, but more often they neglect them and try to ignore them. They let things drift. They admit in a half-hearted way that physical culture is a good thing, but they discourage every development of athletics under student management, while they inaugurate no adequate management of their own. In many cases athletic managers, supported as they are by strong popular favor, are a sort of terror to tutors and professors; they compel them to assist or at least to wink at deception and dishonesty.

It is useless to expect clean athletics when the members of the faculty participate in or condone fraud and unfairness. I do not willingly admit the shortcomings of college officers, but their own confessions can not be gainsaid. I know of no more corrupting influ-

* Read before the Society for the Promotion of Engineering Education, Pittsburgh meeting, July, 1902.

ence upon students than a dishonest faculty. You would be astonished and mortified if you knew the extent to which professors in reputable institutions make false returns of the standing of players supposed to be indispensable to the success of a college team. The excuses they offer are that they must make allowance for different standards, and hence some 'diplomacy' is necessary to secure a fair game; and secondly that the demand for leniency is so strong that it becomes a duty to the institution they represent to exercise a discreet indulgence. It is extremely discouraging, it is said, to make a poor showing in what are popularly held to be manly sports, through the maintenance of high standards of scholarship. In one institution a student is held to be disqualified by dropping below an average grading of sixty or seventy per cent.; in another he is allowed to 'pass' on an average of thirty or forty per cent. Similarly the phrases 'college grade' and 'post-graduate' mean little or much according to usage. It is clear that the temptations to place new and unwonted meanings to the word 'conditioned' are very strong.

Has not the time arrived for a general conference of representatives from all institutions for higher education, whether literary or technical, for the purpose of formulating rules and adopting uniform standards in so far as they bear upon the question of eligibility to athletic teams? All admit that high standards are necessary in determining a man's worthiness to be proclaimed an attorney, an architect, an engineer or a physician; while a more moderate standard may be admissible in the general studies which are regarded as in no way professional. A university may require a passing grade of forty per cent. in its college of letters, but insist upon sixty or seventy per cent. in its schools of engineering, law and medicine. Evidently there should be no such discrepancy in determining athletic eligibility for intercollegiate games.

Local conferences have already been held, but I suggest an effort to bring together all institutions east, west, north and south, and if possible to adopt standards and rules that all can faithfully observe. My object to-day is to lay before you some considerations in favor of the systematic management of both domestic and intercollegiate athletics in every school or college of engineering, and to submit some practical suggestions in regard to the latter feature.

I have recently given some thought to manly sports, and I venture a few words in regard to their value in every scheme of all-round education.

The General Value of Systematic Athletics.

The modern development of athletics has resulted from a combination of causes. The physical asceticism of the middle ages has

passed away. Muscular Christianity is now the rule and not the exception. A weak, stunted and famished body is no longer regarded as a sure abode, not even as a promise, of a purified, robust spirit. The Roman motto of a sound mind only in a sound body is in universal favor.

Again, a continually diminishing proportion of the people are engaged in reducing the wilderness, in raising the crops and in rearing the stock which are needed for food; and as for the rest of us, we are walled up in great cities, roofed in from the sunlight and pure air, and then given a maximum of brain work with as little as possible of physical exercise. This state of things can not long endure without serious injury to our manhood. Close observers of the American people state that nervous diseases and all complaints arising from excessive brain work, combined with a lack of physical health and vigor, are steadily increasing, and if we would avert the threatened physical degeneracy of our nation we must consciously introduce physical culture and athletic games which shall strengthen our bodies and invigorate our minds.

The army and navy draw but a very small fraction of our youth to the fascinations of military or marine life, and even the cadets must have their sports and games in addition to the routine of drill.

Perhaps we can leave mere fun to the children, but contests which tax one's strength and skill have perpetual charm for young men who are at an age to be delightfully conscious of their strength, and increasingly ambitious to exhibit their skill. Now, more than ever in history, opportunities for exhibiting strength and skill in competition must be manufactured. In primitive days the young farmer, the builder, the hunter, the soldier, found abundant opportunity to exhibit his prowess without modern athletics. The marked development of athletics during the last four years is due to no change in the mental, moral and physical tastes and appetites of young men, but to a social development which renders necessary special provision for the gratification of those normal tastes and appetites.

Manly Sports vs. Gymnastics.

I find it necessary to make a distinction between manly sports and gymnastics. They agree generally in affording athletic culture, but they differ in the order of importance they attach to exercise and to sport. Gymnastic training makes the exercise the main thing, while the pleasure and passion for competition and victory are secondary. It is just the other way with athletic games; with them the game is foremost, while the physical and moral benefits are incidental.

'Athletics begin where gymnastics leave off.' There is no antag-

onism between them; the one supplements the other. Every participator in field sports should bring to his games a body well developed by judicious gymnastic training. On the other hand the trained gymnast is entitled to the peculiar delights and rewards of athletic games.

The Relation of Physical to Mental Vigor.

There is in the minds of many people a natural and reasonable fear that an enthusiasm for athletics involves a loss of interest in scholarship, in the high ideals of the spirit and in the details of a chosen course of study. It is feared that even when one does not lose his interest in study in consequence of his interest in athletics, he must suffer a loss of the time which athletics require. I doubt if any of these fears are well grounded. There is great economy of time in spending a proper amount of it in healthful, invigorating exercise; and again there is a great waste of time in lingering and poring long over one's books. On this point I can speak from considerable experience and observation. Again and again I have felt it my duty to order students to close their books and go out for exercise or for a game. The physical ills that students suffer from as a rule arise from too little exercise, not from too much.

Says Dr. Mitchell, of Philadelphia, in a little book labeled 'Wear and Tear': 'A proper alternation of physical and mental labor is fitted to insure a lifetime of wholesome and vigorous intellectual exertion.'

Again he says: 'Eat regularly and exercise freely, and there is scarce a limit to the work you may get out of the thinking organs.' Mental action is a distinctly physical process. Without the free circulation of blood in the brain there can be neither thought nor sensation, emotion nor ideas, and the quality of the mental action is largely dependent upon the quality of this supply of blood. Here then seems to lie the solution of this vitally important problem. We succeed best not by diminishing the amount of brain work, but by so regulating the manner of our lives as to make that amount of work harmless. The time we spend in judicious and absorbing exercise is not lost.

Will you pardon me for drawing upon my personal experience? I am old enough to draw some safe conclusions as to the immediate and permanent value of moderate athletics.

When I entered Harvard there was no gymnasium, no baseball, no Rugby football, no athletics of any kind except rowing, and that was too expensive for me. So I got on a while without any exercise. I had always been accustomed to an active life on a farm, and I was soon in a bad way. Fortunately my people became alarmed and insisted upon my joining a boat club; so I joined a club near the end of my

Freshman year. I enjoyed the sport, became a 'good oar,' and rapidly recovered my strength and vigor. From that time I joined regularly in the sports of the seasons as they came round. I have a set of heavy Indian clubs which I have used for forty-five years.

During my Senior year in college a vacancy occurred in the university crew and it seemed to be necessary for me to pull an oar in the 'Harvard.' There were special reasons for hard study in a particular direction on my part, and I was very unwilling to abridge or interfere with my hours for work. Moreover, I was a member of a cricket club which had been challenged to play by a lower class, and I could not refuse to meet with the club during practice hours.

Meanwhile, I had, of course, my daily lessons and exercises to prepare, and the regular recitations and lectures to attend. With reason, I said that my hands were already full; and yet the case was so urgent, and I loved rowing so much, that I concluded to try the experiment and see if, with more regular habits of eating and sleeping, and a steady, hard pull of eight miles per day, I could not do as much work in the time that remained as I had been accustomed to. I drank neither tea nor coffee, used no tobacco, and indulged in neither wine nor beer; I ate neither puddings nor pies, strawberries nor ice cream. My diet was chiefly beef, mutton, potatoes, oatmeal, bread and milk. I went to bed at ten o'clock. To my surprise, I found I could do about two hours' steady work in one, my head was as clear as a bell, I was as strong as an ox, and I had never felt so gloriously in my life. I should add that I have never had any reason to regret the decision I then made.

My own experience thus confirms the statement of Dr. Mitchell, and I have no doubt that your experience and observation point in the same direction. One conclusion then seems to be reached: To be able to perform our intellectual labor successfully, we must alternate it with active exercise which is intense enough to absorb the attention without taxing those areas of the brain that need rest. Such active exercise as a general thing is found in the manly sports. Therefore, our intellectual well-being demands as a general thing that we participate in them rationally and regularly.

The Moral Influence.

But there is more in athletics than mere physical and mental health. There is a moral training which is of equal if not of greater value. One acquires from successful athletics as from gymnastics a mental dexterity which is of infinite worth. In an emergency, one must not lose his head or forget his hands. Be it a shipwreck, a midnight fire, a school panic, a summer camp—the man of brain and brawn is a saving help.

The moral and mental value of high-class athletics is well pointed out by the late President Francis A. Walker:

> It must be said that the favorite athletics of to-day are, in great measure, such as call for more than mere strength and swiftness. They demand, also, steadiness of nerve, quickness of apprehension, coolness, resourcefulness, self-knowledge, self-reliance; further still, they often demand of the contestants the ability to work with others, power of combination, readiness to subordinate individual impulses, selfish desires, and even personal credit, to a common end. These are all qualities useful in any profession; in some professions they are of the highest value. So genuine does this advantage appear to me that were I Superintendent of the Academy at West Point, I should encourage the game of football among the cadets as a military exercise of no mean importance. It is the opinion of most educated Englishmen that the cultivation of this sport has had not a little to do with the courage, address, and energy with which the graduates of Rugby, Eton, and Harrow, have made their way through dangers and over difficulties in all quarters of the globe.

Rugby football has taken a strong hold upon popular favor and no outdoor entertainment can command so large an attendance of respectable people as a game of football between two teams of college boys. Of course there is mixed with a love of the game pure and simple a great deal of college spirit and college pride.

But there is something more. There is a moral force that is mighty and strong, and which only a player truly knows. The player alone feels the wild joy of the charge, the struggle, the tackle and the gauntlet. None but the player feels the absolute necessity of obeying orders, of cooperation, of vigilance, of instant decision and prompt action. A novice at the game subordinates the care of the ball to the care of himself; he can not help this; he feels that his person is worth any number of points in the game, and he risks a defeat to avoid a bruise or a sprain; but when he is trained and can fall safely without thinking of himself, he subordinates himself to the requirements of the game and puts his whole soul as well as his body into the play.

Experienced players can see great moral gain in all this, and in the sense of obligation to cherish the body so that it may always be at its best. Men who have made athletics a business have taught us that certain things weaken and enervate a man and make him less noble and less manly; so the football player must avoid them, not only while he plays, but as long as he wishes to be noble and manly.

President Thwing's Views.

In a recent number of the *North American Review,* President Thwing of the Western Reserve University elaborates 'The Ethical Functions of Football.' His points are summarized as follows: (1) Football represents the inexorable. It embraces things that must be done at specific times, places and in specific ways. (2) Football

illustrates the value of the positive. It teaches one to do. It is action, not inaction. It bucks, it punches, it breaks, it runs, it goes, it goes through the line, it goes round the ends, but it goes. (3) Football represents the value of a compelling interest. There are other interests, good and bad, but certain temperaments need something like football to arouse them. Speaking of a lazy boy, Emerson said: 'Set a dog on him, send him West, do something to him.' Football serves such a purpose. (4) Football embodies the process of self-discovery. Every football game is a crisis. It not only creates power and develops power; it also discovers the possession or the lack of power. (5) Football develops self-restraint. Self-restraint, or more broadly, self-control, is one of the primary signs of the gentleman. Football demands self-restraint for it teems with temptations to do mean and nasty things. It thus helps to make the finest type of a gentleman.

Few college men would claim all the above, but if we grant the half, football is amply justified, and deserves general support.

It is interesting to note the favor with which athletics are received by educational leaders on all sides. I quote a paragraph from Supt. Thomas M. Balliet, one of the ablest of Massachusetts educators:

> The need of systematic physical training as a part of the legitimate work of the public schools is to-day not questioned by anyone who is informed on the subject. The health and care of the body is as much the concern of the school as the training of the mind, and this fact is coming to be very widely recognized by school committees. . . . The best authorities on physical training place much less emphasis at present than formerly on formal gymnastics, and far more on free, spontaneous outdoor play as a means of physical culture.

Unmanly Interference.

In the interest of fairness and good breeding General Walker protests vigorously against a style of systematic cheering or yelling, which directly or indirectly tends to disconcert and impede opposing players. In this protest I cordially join. Good play should be generously recognized no matter who makes it, and neither the side lines nor the grand stand should say or do anything to embarrass or confuse visiting players. It ceases to be a manly sport when ungentlemanly tricks are resorted to. Fair play means the golden rule; treat others as you would wish to be treated in a similar situation. I do not say, as you would *expect* to be treated, but as you would *wish* to be treated. I regret that in many a community visiting clubs are treated by the spectators in such a disgraceful way that one is forced to infer that they do not know what fair play and good breeding mean.

Last spring I witnessed some athletic contests between the representatives of different educational institutions in a neighboring park. One

institution was represented by a big-mouthed man who sat on a front seat, and made rude and insulting remarks in a loud voice just when men whom he wished to disconcert were on the point of a jump or a vault or a throw. I had no interest in any particular player, but I was intensely disgusted at that man's behavior, and I felt deeply humiliated to find myself in such company. Had I been clothed with the proper authority, I would have had that boor promptly expelled from the park. I have witnessed other exhibitions of unfairness and bad manners on the part of the spectators, and I have felt ashamed for my city and State, but nothing quite as bad as that I saw last spring. I hope no such unfairness will ever be seen on your campus or on mine. We must train our audiences 'to be as virtuous and as impartial as the Greek chorus, to the end that the game may be played by the players and not by the spectators'. We

> **Must set the cause above renown,**
> **And love the game beyond the prize.**

Professionalism has been the curse of intercollegiate contests in many of the younger and smaller institutions of the west. Even in the east, eligibility rules have been agreed to with difficulty, and then readily evaded or ignored. It has been rare to find a college team where every member was a *bona fide* student playing without compensation in some shape or form, such as remittance of fees and dues, payment of personal expenses, or excuse from lectures and examinations; while veteran players, almost gray in athletic service, are received under the ample cloak of 'post-graduates.'

I close with some practical suggestions based upon my experience as chairman of an athletic board, and upon a study of the conditions which obtain elsewhere.

The following rules and definitions are respectfully submitted:

Eligibility.

1. To be eligible to membership in a team representing the institution one must be a *bona fide* student, doing full work as a 'regular' or a 'special.'

2. His average scholastic standing must not be less than sixty per cent. and in no single branch or study shall his record for the last quarter be less than fifty per cent.

3. If a 'dropped' student, or a 'not-promoted' student, he shall not be eligible till after one year, either in the same department or in a different department. (For example, a student not-promoted in a school of engineering can not secure eligibility by withdrawing and entering the college of letters or the law school.)

4. He must not have been a representative college athlete for four years either in one, or more than one, institution. The four years begin with the date of his first appearance on a representative team; no allowance is to be made for not playing, except in the case of exclusion under Rule 3.

5. He must hold a certificate of actual physical soundness, and a muscular development sufficient to justify his taking part in a proposed athletic contest; this should be signed by the gymnastic director if a physician, or by the highest medical authority connected with the institution.

6. He must be able to swim if he proposes to row in a college boat either for practice or in a regatta.

7. He must not be in arrears to the local athletic association.

8. He must not be receiving and must never have received compensation for playing or teaching others to play athletics. Compensation is here held to include not only salary, but rebates and remission of fees, ordinary personal expenses, a share in the gate money, or financial aid in any other direct or indirect form.

9. He must be free or acquitted of all charges of improper and ungentlemanly conduct in his athletic record.

All the above rules shall hold as well for substitutes and ranking candidates for positions on a college team.

Miscellaneous Rules.

1. An athletic committee appointed by the president or elected by the faculty shall represent the faculty and board of control in all athletic matters. The chairman shall certify to the eligibility of every man on the team, and whenever asked for it he shall furnish a certified copy of the athletic record of any man on the team.

2. The athletic committee shall pass upon the time, place and conditions of a proposed intercollegiate contest, and shall determine the amount of absence from college exercises a member of the team may have during a season.

3. The athletic committee shall at all times be free to examine and audit the accounts of the treasurer of the athletic association.

4. Contracts for coaches, trainers, grounds, etc., shall not be valid until approved by the athletic committee.

5. Except for practice and informally, *i. e.*, not for public exhibition, a university team shall not play with teams from preparatory schools nor with teams from non-educational institutions.

6. No university team shall play formally or informally with a professional team or with a team containing professional players.

7. A university team shall not play with the team of another college or university unless every member of the opposing team be eligible under rules substantially the same as above.

8. No personal expenses for travel, clothing, training or medical attendance shall be paid for students not enrolled as members of teams and substitutes.

9. If a member of a team becomes ineligible for any reason, he shall at once be dropped from the team and a promotion shall be made from the waiting list.

10. If a player be dropped from a team on account of delinquency or dishonorable conduct, he shall at once cease to wear athletic honors in the way of numerals or letters.

11. Members of a university team shall not have played on a team of similar character during the preceding summer vacation.

12. Managers of teams shall be elected by the athletic association.

13. Each team of actual players shall at the end of a season elect the captain for the succeeding season.

14. Managers in consultation with the athletic committee shall make up the schedule of games for the season.

15. Captains with the approval of the athletic committee shall make up their teams from the eligible lists.

The object of all athletic organizations shall be understood to be chiefly the following, arranged in the order of importance, the most important first:

(*a*) Physical culture, with the mental alertness and moral stability which follows in its train; consequently the greater the number and variety of athletic games and teams the better.

(*b*) To meet the normal and healthy demand of young men for manly sports, for recreation and relaxation, and to relieve the tedium of much study.

(*c*) To foster to a reasonable extent local pride and emulation, to create an *esprit de corps,* and to promote harmony and good-fellowship between students and faculty and between different departments.

(*d*) To advertise a college or university by arousing an interest among preparatory students and others who otherwise might never be attracted to the advantage and enjoyments of higher education.

To secure these objects every student should be encouraged on entrance to immediately submit himself to a physical examination, and with the advice of the physical director or the athletic committee not only begin regular gymnastic practice, but join a branch of the association devoted to systematic practice in some athletic game.

Every program of hours in a school of engineering as well as in a college of letters should recognize the demands of rational athletics.

RECENT ADVANCES IN SCIENCE, AND THEIR BEARING ON MEDICINE AND SURGERY.*

By Professor RUDOLF VIRCHOW.

THE honor of being invited to deliver the second Huxley lecture has deeply moved me. How beautiful are these days of remembrance which have become a national custom of the English people! How touching is this act of gratitude when the celebration is held at the very place wherein the genius of the man whom it commemorates was first guided toward its scientific development! We are filled not alone with admiration for the hero, but at the same time with grateful recognition of the institution which planted the seed of high achievement in the soul of the youthful student. That you, gentlemen, should have entrusted to a stranger the task of giving these feelings expression seemed to me an act of such kindly sentiment, implying such perfect confidence, that I at first hesitated to accept it. How am I to find in a strange tongue words which shall perfectly express my feelings? How shall I, in the presence of a circle of men who are personally unknown to me, but of whom many knew him who has passed away and had seen him at work, always find the right expression for that which I wish to say as well as a member of that circle itself could? I dare not believe that I shall throughout succeed in this. But if, in spite of all, I repress my scruples it is because I know how indulgently my English colleagues will judge my often incomplete statements, and how fully they are inclined to pardon deficiency in diction if they are convinced of the good intentions of the lecturer.

Professor Huxley's Work.

I may assume that such a task would not have been allotted to me had not those who imposed it known how deeply the feeling of admiration for Huxley is rooted within me, had they not seen how fully I recognized the achievements of the dead master from his first epoch-making publications, and how greatly I prized the personal friendship which he extended toward me. In truth, the lessons that I received from him in his laboratory—a very modest one according to present conditions—and the introduction to his work which I owe to him form

* The second Huxley lecture, delivered at the opening of the winter session of Charing Cross Hospital Medical School, on October 3, 1898. Originally printed in the London *Times*.

one of the pleasantest and most lasting recollections of my visit to Kensington. The most competent witness of Huxley's earliest period of development, Professor Foster, presented in the first of these lectures a picture of the rapidly increasing extension of the biological knowledge which must have excited not only our admiration but also the emulation of all who study medicine. Upon me the duty is incumbent of incorporating with this presentment the newer strides of knowledge and of stating their influence upon the art of healing. So great a task is this that it would be presumptuous even to dare to attempt its accomplishment in a single lecture. I have decided, therefore, that I must confine myself to merely sketching the influence of biological discoveries upon medicine. In this way, also, will the example of Huxley be most intelligible to us. I must here make a confession. When I tried to ascertain how much time would be required to deliver my lecture as I had prepared it, I found, to my regret, that its delivery would occupy nearly double the time assigned to me. I had therefore to reduce it to about half of its original dimensions. This could only be done by means of very heroic cuts, seriously damaging in more than one place my chain of ideas.

The Beginnings of Biology.

Huxley himself, though trained in the practical school of Charing Cross Hospital, won his special title to fame in the dominion of biology. As a matter of fact, at that time even the name of biology had not come into general use. It was only recently that the idea of life itself obtained its full significance. Even in the late Middle Ages it had not sufficient strength to struggle through the veil of dogmatism into the light. I am glad to be able to-day for the second time to credit the English nation with the service of having made the first attempts to define the nature and character of life. It was Francis Glisson who, following expressly in the footsteps of Paracelsus, investigated the *principium vitæ*. If he could not elucidate the nature of life, he at least recognized its main characteristic. This is what he was the first to describe as "irritability," the property on which the energy of living matter depends. How great was the step from Paracelsus to Glisson and, we may continue, from Glisson to Hunter! According to Paracelsus life was the work of the special *spiritus*, which set material substance in action, like a machine; for Glisson, matter itself was the *principium energeticum*. Unfortunately, he did not confine this dictum to living substances only, but applied it to substance in general, to all matter. It was Hunter who first announced the specific nature of living matter as contrasted with nonliving, and he was led to place a *materiæ vitæ diffusa* at the head of his physiological and pathological views. According to the teaching of Hewson and Hunter, the blood

supplied the plastic materials of physiology as well as the plastic exudates of pathology. Such was the basis of the new biological method, if one can apply such an expression to a still incomplete doctrine, in 1842, when Huxley was beginning his medical studies at Charing Cross Hospital. It would lead too far afield were I to recount in this place how it happened that I myself, like Huxley, was early weaned from the pernicious doctrines of humoral pathology.

The Development of Biology.

When Huxley himself left Charing Cross Hospital, in 1846, he had enjoyed a rich measure of instruction in anatomy and physiology. Thus trained, he took the post of naval surgeon, and by the time that he returned, four years later, he had become a perfect zoologist and a keen-sighted ethnologist. How this was possible anyone will readily understand who knows from his own experience how great the value of personal observation is for the development of independent and unprejudiced thought. For a young man who, besides collecting a rich treasure of positive knowledge, has practiced dissection and the exercise of a critical judgment, a long sea voyage and a peaceful sojourn among entirely new surroundings afford an invaluable opportunity for original work and deep reflection. Freed from the formalism of the schools, thrown upon the use of his own intellect, compelled to test each single object as regards properties and history, he soon forgets the dogmas of the prevailing system and becomes first a skeptic and then an investigator. This change, which did not fail to affect Huxley, and through which arose that Huxley whom we commemorate to-day, is no unknown occurrence to one who is acquainted with the history not only of knowledge, but also of scholars. We need only to point to John Hunter and Darwin as closely allied examples. The path on which these men have achieved their triumphs is that which biology in general has trodden with ever-widening strides since the end of last century—it is the path of genetic investigation. We Germans point with pride to our countryman who opened up this road with full conviction of its importance, and who directed toward it the eyes of the world—our poet-prince Goethe. What he accomplished in particular from plants others of our fellow-countrymen achieved from animals—Wolf, Meckel, and our whole embryological school. As Harvey, Haller, and Hunter had once done, so these men began also with the study of the 'ovulum,' but this very soon showed that the egg was itself organized, and that from it arose the whole series of organic developments. When Huxley, after his return, came to publish his fundamental observations, he found the history of the progressive transformations of the contents of the egg already verified, for it was by now known that the egg was a cell, and that from it fresh cells and

from them organs arose. The second of his three famous papers—that on the relationship between man and the animals next beneath him—limned in exemplary fashion the parallelism in the earliest development of all animal beings. But beyond this it stepped boldly across the border line which tradition and dogma had drawn between man and beast. Huxley had no hesitation in filling the gaps which Darwin had left in his argument, and in explaining that "in respect of substance and structure man and the lower animals are one." Whatever opinion one may hold as to the origin of mankind, the conviction as to the fundamental correspondence of human organization with that of animals is at present universally accepted.

Omnis Cellula e Cellula.

The greatest difficulty in the advance of biology has been the natural tendency of its disciples to set the search after the unity of life in the forefront of their inquiries. Hence arose the doctrine of vital force, an assumption now discarded, but still revealing its influence from time to time in isolated errors. No satisfactory progress could be made till the idea of highly organized living things as units had been set aside; till it was recognized that they were in reality organisms, each constituent part of which had its special life. Ultimate analysis of higher animals and plants brings us alike to the cell, and it is these single parts, the cells, which are to be regarded as the factors of existence. The discovery of the development of complete beings from the ova of animals and the germ-cells of plants has bridged the gap between isolated living cells and complete organisms, and has enabled the study of the former to be employed in elucidating the life of the latter. In a medical school where the teaching is almost exclusively concerned with human beings this sentence should be writ large: "The organism is not an individual, but a social mechanism." Two corollaries must also be stated—(1) that every living organism, like every organ and tissue, contains cells; (2) that the cells are composed of organic chemical substances, which are not themselves alive. The progress of truth in these matters was much retarded by that portion of Schwann's cell theory, which sought to establish the existence of free cell formation, which really implied the revival of the old doctrine of spontaneous generation. This belief was gradually driven out of the domain of zoology, but in connection with the formation of plastic exudates found a sanctuary in that of pathology. I myself was taught the discontinuity of pathological growths—a view which would logically lead back to the origin of living from nonliving matter. But enlightenment in this matter came to me. At the end of my academical career I was acting as clinical assistant in the eye department of the Berlin Hospital, and

I was struck by the fact that keratitis and corneal wounds healed without the appearance of plastic exudation, and I was thus led to study the process of inflammation in other nonvascular structures, such as articular cartilages and the intima of the larger vessels. In no one of these cases was plastic exudation found, but in all of them were changes in the tissue cells. Turning next to vascular organs, and in particular those which are the common seats of exudation processes, I succeeded in demonstrating that the presence of cells in inflammatory exudates was not the result of exudation, but of multiplication of preexisting cells. Extending this to the growth in thickness of the long bones—which was ascribed by Duhamel to organization of a nutritious juice exuded by the periosteal vessels—I was thus eventually able to extend the biological doctrine of *omnis cellula e cellula* to pathological processes as well; every new formation presupposing a matrix from which its cells arise and the stamp of which they bear.

Heredity.

Herein also lies the key to the mystery of heredity. The humoral theory attributed this to the blood, and based the most fantastic ideas upon this hypothesis. We know now that the cells are the factors of the inherited properties, the sources of the germs of new tissues and the motive power of vital action. It must not, however, be supposed that all the problems of heredity have thus been solved. Thus, for instance, a general explanation of theromorphism, or the appearance of variations recalling the lower animals, is still to be found. Each case must be studied on its merit, and an endeavor made to discover whether it arose by atavism or by hereditary transmission of an acquired condition. As to the occurrence of the latter mode of origin, I can express myself positively. Equally difficult is the question of hereditary diseases; this is now generally assumed to depend on the transmission of a predisposition which is present, though not recognizable, in the earliest cells, being derived from the parental or maternal tissues. But the most elaborately constructed doctrines as to the hereditariness of a given disorder may break down before the discovery of an actual causa viva. A notable example of this is found in the case of leprosy, the transmission of which by inheritance was at one time so firmly believed in that thirty years ago a law was nearly passed in Norway forbidding the marriage of members of leprous families. I myself, however, found that a certain number of cases at any rate did not arise in this way, and my results were confirmed by the discovery of the leprous bacillus by Armauer Hansen. In a moment the hereditary theory of the disease was overthrown and the old view of its acquirement by contagion restored. Precisely the same happened a few decades earlier with regard to favus and scabies. Another instructive

condition is that known as Heterotopia, in which fragments of tissues or organs are found dwelling in a situation other than that which is normal to them. This is particularly the case with certain glands, such as the thyroid and suprarenal, but is also known with cartilage, teeth, and the various constituents of dermoids. It no doubt occurs by process of transplantation, the misplaced tissues developing no new properties, but merely preserving their normal powers of growth. The attempt to generalize from this fact and to attribute all tumor formations to this cause carries the idea beyond its proper scientific limits.

Parasitism and Infection.

With regard to the subject of parasitism, the progress of scientific observation was retarded for centuries by the prevalence of the assumption made by Paracelsus that disease in general was to be regarded as a parasite. Pushed to its logical conclusion, this view would imply that each independent living part of the organism would act as a parasite relatively to the others. The true conception of a parasite implies its harmfulness to its host. The larger animal parasites have been longest known, but it is not so many years since their life history has been completely ascertained and the nature of their cysts explained, while an alternation of generations has been discovered in those which are apparently sexless. Very much more recent is the detection of the parasitic protozoa, by which the occurrence of the tropical fevers may be explained. As yet we have not complete knowledge as to their life history, but we hold the end of the chain by which this knowledge can be attained. The élite of the infectious diseases are, however, the work of the minutest kind of parasitic plants, bacteria, the scientific study of which may be said to date from Pasteur's immortal researches upon putrefaction and fermentation. The observation of microbes under exact experimental conditions, and the chemical investigation of their products opened up the modern field of bacteriology, a science among the early triumphs of which were the discoveries of the bacilli of tubercle and Asiatic cholera by Robert Koch. In connection with this subject three important landmarks require comment. One is the necessity for distinguishing between the cause and the essential nature of infectious diseases, the latter of which is determined by the reaction of the tissues and organs to microbes. Secondly, there is the relation between the smaller parasites and the diseases determined by them. This may be summed up in the general word [introduced by Professor Virchow himself] "infection." But to assume that all infections result from the action of bacteria is to go beyond the domain of present knowledge, and probably to retard further progress. The third point is the question as to the mode of action of infection. It is only the larger parasites

whose main effect is the devouring of parts of their hosts; the smaller act mainly by the secretion of virulent poisons. The recognition of this latter fact has led to the brilliant work of Lister on the one hand and to the introduction of serum therapeutics on the other.

Antiseptic Surgery.

It would be carrying coals to Newcastle were I to sketch in London the beneficial effects which the application of methods of cleanliness has exercised upon surgical practice. In the city wherein the man still lives and works who, by devising this treatment has introduced the greatest and most beneficent reform that the practical branches of medical science have ever known, everyone is aware that Lord Lister, on the strength of his original reasoning, arrived at practical results which the new theory of fermentative and septic processes fully confirmed. Before anyone had succeeded in demonstrating by exact methods the microbes which are active in different diseases, Lister had learned, in a truly prophetic revelation, the means by which protection against the action of putrefactive organisms can be attained. The opening up of further regions of clinical medicine to the knife of the surgeon and a perfect revolution in the basis of therapeutics have been the consequence. Lord Lister, whom I am proud to be able to greet as an old friend, is already and always will be reckoned among the greatest benefactors of the human race. May he long be spared to remain at the head of the movement which he called into existence.

Artificial Immunization.

It remains for me to say a word concerning the other great problem, the solution of which the whole world is awaiting with anxious impatience. I refer to the problem of immunity and its practical corollary, artificial immunization. It has already happened once that an Englishman has succeeded in applying this to the definite destruction of at least one of the most deadly infectious diseases. Jenner's noble discovery has stood its trial as successfully, except in popular fancy, as he hoped. Vaccine is in all hands; vaccination is, with the aid of governments, spreading continually. Pasteur also labored with determination; others have followed him, and the new doctrine of antitoxines is continually acquiring more adherents. But it has not yet emerged from the conflict of opinions, and still less is the secret of immunity itself revealed. We must become well accustomed to the thought that only the next century can bring light and certainty on this point.

DISCUSSION AND CORRESPONDENCE.

ARE FELLOWSHIPS ALMSGIVING OR INVESTMENTS?

TO THE EDITOR: In the POPULAR SCIENCE MONTHLY for September, page 472, Mrs. W. A. Kellerman asks, 'Are Fellowships Almsgiving or Investments?'

As ordinarily granted in American universities, they may be either. Still more often they are rather advertisements, and they may in any case partake of the nature of all three of these.

The great gifts to education have been for the purpose not of feeding men but of furnishing means of study and investigation beyond the reach of individual effort. This is 'investment put to the credit of the country's future.' The ordinary fellowship furnishes not special facilities, but board and lodging for individuals, matters quite within the range of individual effort on the part of almost any student worth educating. It does not increase scholarship but multiplies the number of those who scramble for its rewards. The same amounts expended in better teachers and in better facilities for work would do more for American scholarship than the fellowships now accomplish.

It is understood that the Carnegie gift is to be devoted solely to the promotion of research, not to the encouragement of men who show mere promise of ability. It is to be used to complete the equipment of investigators who have already done all within their power as individuals, and whose lives will be devoted to research whether helped or not. To aid in making their work effective is not almsgiving. If any part of the fund is used to hire men to undertake research, it will be wasted, and the trustees of the fund will have to resist many temptations to do this.

The fellowship is now largely used as a means of university advertisement, to the real injury of higher education. To induce any man to go where he does not wish to go or to study what he would not otherwise have cared for is to cheapen higher education.

Real scholars will work out their own salvation, so far as the cost of education is concerned. Real universities are built up by real investigators. To furnish these and their students with books, implements and materials will bring students worthy of the opportunity. To give students that which they need in their work and can not buy for themselves is to draw the line between 'investment' and 'almsgiving.'

Certainly the whole American 'system of fellowships for advanced students is now on trial with most of the evidence against it.'

DAVID S. JORDAN.

COLLEGE PROFESSORS.

TO THE EDITOR: I have read with interest Professor Stevenson's article in the September number of the MONTHLY. It is sane and well considered. Two of his generalizations are however not based on a sufficient number of data. In speaking of the college professors of a generation ago he says, 'The hours of teaching were short.' In so far as this was the case I believe it was the exception rather than the rule. Not long ago a professor who began to teach in the fifties remarked to me incidentally in a conversation, 'For many years I taught all the time and so did my colleagues.'

Several instances almost similar are within my knowledge. It has been said of a prominent college not fifty miles from Philadelphia that its trustees had for many years a regulation threatening with dismissal any professor who published a book. They wished to have it understood that professors were expected to devote all their time to teaching and that the writing of books was equivalent to depriving their students of what clearly belonged to them. Perhaps it would not be easy to find a board at this time that takes such a view, but individual members are not rare. That man is most acceptable who can, or thinks he can, teach the largest number of subjects. Again, there may be many high schools that do the excellent work Professor Stevenson had in mind; I have no desire to belittle it or them. On the other hand I am sure there is a far larger number, taking the country as a whole, in which, for various reasons, the instruction is very inferior and the graduates of which could not be admitted into any reputable college unconditioned. Furthermore, I believe the three following propositions can be sustained: (1) The average ability of college professors is not higher than that of the legal or medical profession, if we include among the latter only those members who have had collegiate training in addition to their professional education. That they are generally men of wider information most people will admit. (2) That speaking by and large those college professors who have had adequate preparation can find time for original work, if they desire. Of the professors in the college from which I graduated, about a dozen in all, two were constantly carrying on original investigations; yet they had no more time but rather less than their colleagues. Very often the college professor makes deliberate choice between two courses open to him: either he will employ his spare time in keeping abreast of the advances in his own department and in preparing to present this fresh knowledge most effectively to his classes, or in original researches. Few men can do both. (3) College professors on the average get as much satisfaction out of life as any other class. It may be assumed that the young man who enters deliberately upon the profession of teaching does so in response to a 'call,' that is, because it represents the work he feels best fitted to perform. Of the men who engage in the quest for money the large majority is disappointed. The pleasure of the pursuit is conditioned upon possession; but when they fail in securing possession their labor and self-denial have been in vain. Not so with him who is engaged in seeking and imparting knowledge. Few persons have a large preponderance of the good things of this life. He who dwarfs his mind by bending all his energies to the acquisition of wealth effectually closes it to esthetic enjoyment. If all men were permitted to fix the pecuniary compensation for their services we should see some curious estimates. Few are satisfied with what they get. Our frequent strikes are evidence that labor is as discontented as teaching. Most persons who give their services for pay get all they can; it is the philosophically inclined who grumble least over the amount. College professors above all others need to take to heart the injunction of the poet,

> "With a heart for any fate
> Still achieving, still pursuing,
> Learn to labor and to wait."

He who in the course of a life-time has succeeded in making a few of his students better, wiser, nobler, has not lived to little purpose. He is something more than a 'link in being's endless chain.'

C. W. SUPER.

OHIO UNIVERSITY,
ATHENS, O.

THE PROGRESS OF SCIENCE.

RUDOLF VIRCHOW.

THE world has lost one of its great men in the death of Professor Rudolf Virchow. Born on October 13, 1821, the son of a small shopkeeper and farmer in an obscure village of Pomerania, he died on September 5, known everywhere as one of the greatest if not the greatest of contemporary scientific men, having at the same time performed in his long life public services such as do not ordinarily fall to the lot of the man of science. It is not possible to recount in this place the numerous events of Virchow's career nor to describe his great contributions to science. His 'Cellular Pathology' was published in 1858; his theories and experiments having been in part printed in earlier volumes of the *Archives für pathologische Anatomie und Physiologie*, established by him and Reinhart in 1848. Virchow's main thesis was that the cells of the animal body propagate themselves, and that outside forces acting on the cells produce in them mechanical or chemical changes which are disease. The facts of bacteriology since discovered harmonize with this theory and do not conflict with it as has sometimes been assumed. Virchow more than any other one man established the science of pathology and made it possible for medicine to become an applied science. Only second in importance to his contributions to pathology was his work in anthropology which covered all branches of the science—physical measurements, racial differences, ethnology and even archeology. He did not oppose evolution, having indeed advocated the transmutation of species before Darwin, but he was critical in his attitude toward natural selection.

Virchow's scientific work was singularly complete. He made numerous and exact observations and experiments; he deduced from them wide-reaching theories; he conducted an important journal for more than fifty years; he wrote text-books, summaries of scientific advance and books popularizing science; he established a school to which students came from all parts of the world, while at the same time taking part in the education of the people; he founded a great museum and took a leading part in scientific societies; he applied science directly to human welfare.

It is almost incredible that among these multifarious scientific activities Virchow should have been one of the leading statesmen of his country. Here too his work was wide and long continued. He was a member of the municipal council of Berlin for more than forty years, and through him the hygienic conditions of the capital were revolutionized. He had been a member of the Prussian chamber since 1862 and was for twenty-five years chairman of the committee on finance. He was leader of the radical party in the Reichstag. In his public career he opposed centralization, autocracy and war, and advocated all measures for the welfare of the people. He was at one time compelled to leave the University of Berlin owing to his political activity, but his personality and eminence were such that he was recalled to a professorship in 1856, and he was thereafter the preeminent representative of academic freedom.

In this number of the MONTHLY will be found the Huxley lecture on 'Recent Advances in Science and their Bearing on Medicine and Surgery,'

given three years ago by Virchow in London. The issues for July and August of last year contain a paper by him on the 'Peopling of the Philippines,' translated from the *Proceedings* of the Prussian Academy of Sciences. A recent portrait of Virchow is given above as a frontispiece. An earlier portrait and an account of his life will be found in the number of THE POPULAR SCIENCE MONTHLY for October, 1882.

SCIENTIFIC EMINENCE.

THE death of Virchow, following the deaths of Pasteur, Helmholtz and Darwin, seems to leave the world without men of science as great as those it has lost. Great Britain, in the establishment of its new order of merit, has selected Lord Kelvin, Lord Lister, Lord Rayleigh and Sir William Huggins as the four students of science to be honored. In addition to Mr. Herbert Spencer, whose claims for recognition are somewhat different, Sir Joseph Hooker and Sir William Stokes may be placed in this group. When, on the occasion of Virchow's eightieth birthday last year, Lord Lister brought greetings from Great Britain, he was the only man whose work could be placed beside Virchow's; but while his method of antiseptic treatment in surgery has been one of the greatest advances in medicine, it is in some respects an isolated discovery, and can scarcely claim equality with the immense work accomplished by Virchow and Pasteur. Lord Kelvin is the only living physicist who might be ranked with Helmholtz. Darwin has no peer.

Although Germany has a larger number of scientific workers than Great Britain, it is not certain that it now has more men of exceptional eminence. Professor Haeckel has a world-wide reputation, but would perhaps be ranked less highly by the expert than by the general public. Professor Röntgen's name is known everywhere for one striking discovery, as are also Professor Weismann's for a theory around which much discussion has collected, and Dr. Koch's, less for his real work than for sensational expectations. But it may be doubted whether the leading German men of science are known to the general public or even to those in other departments of science. They would include Klein in mathematics, Struve in astronomy, Boltzmann in physics, Ostwald in chemistry, Suess in geology, Koelliker and Gegenbaur in anatomy, Pflüger in physiology, Strasburger in botany and Wundt in psychology. These, and others who might be named with equal justice, form an important group, and several of them are still in the prime of life. It is doubtful, however, whether any of them will attain the eminence of Helmholtz and Virchow.

A similar list for France would include the names of Hermite and Poincaré in mathematics, Loewy in astronomy, Cornu in physics, Berthelot and Moissan in chemistry, Gaudry in geology and van Tieghem in botany. No other European nation ranks with Great Britain, Germany and France. Russia has Mendeléef in chemistry, Kovalevskij in zoology and Karpinskij in geology; Italy has Cremona in mathematics, Righi in physics and Mosso in physiology; and there are of course many other notable men in these and in other countries.

It is obviously difficult to compare our own eminent men with those of other nations. Among those who have an international reputation are Newcomb, Hall and Hill in astronomy, Willard Gibbs in theoretical physics, Michelson in experimental physics, Wolcott Gibbs in chemistry, Gilbert in geology, Agassiz in zoology, Farlow in botany, Welch in pathology and James in psychology.

Eminence is relative, and as scientific work becomes more widespread and special it may be that men of equal ability will no longer become as eminent as might have been the case

had they lived earlier. The complexity of knowledge and of civilization has increased more rapidly within the past four hundred years than the capacity of the mind. A century ago it might have been almost possible to be personally acquainted with the men of the world who were doing work of importance; now it is not possible to remember their names.

THE NEW BRITISH ORDER AND ACADEMY.

In connection with the order of merit established by King Edward on the occasion of his coronation it is of some interest to note that four men of science—whose names are given above—have been placed among the twelve original members. There are in addition three generals, two admirals, two men of letters and one artist. It would thus appear that one third of the recognition for services rendered to the nation fall to science, twice as much as to letters and humanities and four times as much as to art. The creation of the British order of merit and the selection of its recipients have apparently met with general approval, but its usefulness is not quite obvious. The Prussian order 'Pour le Mérite,' established by Frederick the Great in 1740, was fitted to its age and environment, but it seems somewhat late to found an English imitation. An eminent German resident in America has recently maintained that productive scholarship here suffers because we have no honorary recognitions such as flourish in Germany. It must be admitted that men of science like such honors. Even a man as great as Huxley was obviously pleased at being made a privy councilor and being granted an audience with the Queen. Sir William Thomson was willing to give up the name of his father, himself a professor of mathematics, to become Lord Kelvin, even though he has no heir. It is said that he and Professor Lister were made first baronets and then barons because they have no heirs, a certain amount of property, more likely to be possessed by brewers than by scientific men, being required before a hereditary title is granted. But while men of science may like to be Hofrats, Geheimrats, vons, sirs, lords and LL.D.'s, it is not certain that their work is thereby improved or that these honorary distinctions will survive the twentieth century.

Much the same may be said in regard to the British Academy for the promotion of historical, philosophical and philological studies to which a charter has just been granted by King Edward. In so far as this academy is intended to designate forty-nine 'immortals' in certain departments, permitting them to attach several letters to their names and letting their chief corporate duty be the election of their successors, membership is a kind of order or title which belongs to an aristocratic rather than to a democratic age and people. When academies were established, chiefly in the seventeenth and the first part of the eighteenth centuries, it was possible and desirable for all the scientific men of the nation to meet together for experiment and discussion, and membership in the academy usually carried with it a pension or other tangible advantage. Whether membership in an academy simply as an honorary distinction stimulates scientific work in those who are called and in those who would like to be called is perhaps somewhat analogous to the question as to whether good works are encouraged by the rewards and punishments formerly prominent in theological systems. There is partial truth in Tennyson's verses:

> The man of science himself is fonder of glory, and vain;
> An eye well-practiced in nature, a spirit bounded and poor.

The desire for fame has doubtless been useful in the course of social evolu-

tion, but the time may come when its survival will be a nuisance.

An academy may of course perform valuable services as a center of organization. This is the case with the Royal Society, which to a certain extent corresponds to the continental academies, but with three or four hundred members it is reasonably democratic. As the eighteenth century was the era of academies, the nineteenth was the era of special societies for the separate sciences and of democratic associations for the advancement of science. In the present century specialization will increase still further and men of science will become still more numerous; it will be necessary to replace an aristocracy and a plebescite with a representative form of government.

THE PRESIDENT'S ADDRESS BEFORE THE BRITISH ASSOCIATION.

THE French Association for the Advancement of Science held its annual meeting in August, and the corresponding German and British associations held their meetings in September. Reports of these meetings have not as yet come to hand, except that an abstract of Professor James Dewar's presidential address before the Belfast meeting of the British Association has been cabled to the daily papers. It appears from this report that the address was largely devoted to a review of the progress of physical chemistry, but reference was made to recent munificent benefactions to science and education, especially the gifts of Mr. Carnegie and the late Cecil Rhodes. Professor Dewar said he thought that the means chosen by Mr. Rhodes were not the most effective which could have been selected, but that it must be remembered that Mr. Rhodes's aims were political as much as educational. "He had a noble and worthy ambition to promote the enduring friendship of the great English-speaking communities of the world, and he was probably also influenced by the hope that a large influx of strangers would broaden Oxford's notions."

Referring to Mr. Carnegie's endowment of Scottish universities and the foundation of an institution at Washington as of more direct benefit to higher education than the bequest of Mr. Rhodes, Professor Dewar is reported to have remarked that the establishment of the institution at Washington meant a scouring of the Old World as well as the New for the best men in every department. In fact, he said, the assiduous collecting of brains for the benefit of America was similar to the collecting of rare books and works of art which Americans were now carrying on so lavishly.

Reviewing the meager gifts to the Royal Institution of Great Britain during the past century, he said that, without such endowments as Mr. Carnegie's, the outlook for disinterested research was rather dark. The Carnegie Institution could dispose in one year of as much money as the Royal Institution had expended in a century on its purely scientific work, and it would be interesting to note how far the output of scientific work corresponded to the hundredfold application of money to its production.

Speaking on the subject of applied chemistry, Professor Dewar criticized the 'deplorable backwardness' of Great Britain, as compared with foreign countries. Taking Germany as an example, he declared that, notwithstanding the immense range of chemical industries in which the United Kingdom had once been prominent, Germany today employed a professional staff three times as great as the United Kingdom, and as superior in technical training and acquirements as it was numerically. German chemical manufacturers enjoyed a practical monopoly, which enabled them to exact huge profits from the rest of the world and to establish in an almost unassailable position industries which were largely

founded on basic discoveries made by English chemists, but which had never been properly developed in the land of their birth.

The explanation of this 'disastrous phenomenon' Professor Dewar gave in three words: 'Want of education.' He said it was the failure of schools to turn out, and of manufacturers to demand, properly trained men which explained Great Britain's loss of valuable industries and the country's precarious hold upon others. 'To my mind,' said he, 'the really appalling thing is not that the Germans have seized upon this or the other industry, but that the German population has reached a point of general training and specialized equipment which it will take us two generations of hard and intelligently directed educational work to attain.'

THE INTERNATIONAL COUNCIL FOR THE STUDY OF THE SEA.

THIS Council was constituted at Copenhagen on July 22 by delegates from Great Britain, Germany, Holland, Denmark, Norway, Sweden, Russia and Finland. According to the report in the September number of the *Journal* of the Royal Geographical Society, the principle of simultaneous observations four times a year as the basis of a system of regular observations of temperature, density and plankton was adopted, and the share to be taken in the work by each of the participating nations was practically settled. The two ships which the British Government has voted for the work will undertake periodical trips in the Færoe-Shetland channel and across the northern end of the North Sea, working from a central harbor in Shetland, and also simultaneous trips in the western part of the English channel. The southern half of the North Sea will be investigated by the Dutch, the northern half by the German ships. Denmark undertakes the sea between Færoe and Iceland, while Norway has the heavy task of making observations in the North Atlantic off the extensive western seaboard of Scandinavia. Russia has undertaken similar work along the Murman coast and across Barents Sea to Novaya Zemlya, while the Baltic will be studied in detail by Danish, Swedish, Finnish, Russian and German ships. While the periodical oceanographical trips are the framework of the whole system of observations, they are intended to be connected and completed by observations at fixed stations, such as light-ships and by the cooperation, as far as surface observations are concerned, of regular lines of steamers crossing the North Sea and the Atlantic.

The biological work of the council has been limited, by the conditions which most of the governments concerned have attached to their grants, to the investigation of special problems of urgent practical importance to fisheries. Two such problems were selected. A committee has been charged with the duty of investigating the migrations of such fish as the cod and herring, and another with the investigation of the whole question of overfishing in the parts of the North Sea most frequented by trawlers.

The organization of the central bureau of the Council was also determined, Dr. Herwig being appointed as president. The seat of the bureau is in Copenhagen, and the chief assistant will be Dr. Knudsen, lecturer on physics in the Polytechnic school there. All the publications of the council will be issued by the bureau, which will also form the medium of communication between the various national organizations, the special committees and others.

The international laboratory has been established in Christiania, with Dr. Nansen as honorary director and Dr. Walfrid Ekman as assistant for physical work; an assistant for chemical work is also about to be appointed.

The laboratory will undertake the training of observers for the various national organizations, the testing of instruments, the supply of standard sea-water for controlling salinity determinations, and also gas-analysis. It will also carry out experiments with improved apparatus and methods in order to ensure a degree of accuracy never before aimed at in work at sea. It was recommended that the laboratory should, if possible, be opened in October, and that the periodical cruises be commenced as soon as possible, but at the latest by the spring of 1903.

SCIENTIFIC ITEMS.

DR. ALEXANDER AGASSIZ and Lord Avebury have been appointed members of the Prussian order, 'pour le mérite.' We understand that Dr. Agassiz is the only American on whom this honor has been conferred except the historian Bancroft.—Dr. Wilhelm Wundt, the eminent psychologist and philosopher, celebrated his seventieth birthday on August 16. A volume of researches carried out by his former students was presented to him on the occasion.—M. Levasseur, professor of agriculture at the Collège de France, has been elected president of the French Association for the Advancement of Science. The Association will hold its meeting in 1903 at Angiers.—The Iron and Steel Institute of Great Britain held its meeting at Düsseldorf last month. Among those who made addresses at the opening meeting was Professor Henry M. Howe, of Columbia University. Mr. Andrew Carnegie has been elected president of the Institute.—The centenary of the birth of Hugh Miller was celebrated at Cromarty on August 22. The principal address was made by Sir Archibald Geikie. An address was also made by Dr. John M. Clarke, of Albany.—The centenary of the birth of the eminent mathematician, Abel, was celebrated at Christiania last month. On this occasion honorary degrees were given to a number of mathematicians, including Professors Simon Newcomb and J. Willard Gibbs.—The committee of the fund raised to commemorate the eightieth birthday of Professor Virchow announces that it has handed over a sum of over $12,000 to the Rudolf Virchow Foundation.—Gilbert White's house at Selbourne is for sale, and the suggestion is made by Mr. E. A. Martin, member of the council of the Selbourne Society, that it should be purchased as a permanent memorial of the father of British naturalists.

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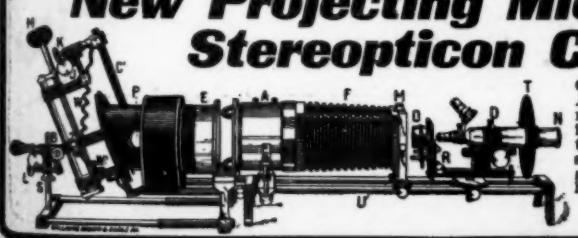

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